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MARCH, 1945

The Radio Amateurs' Journal

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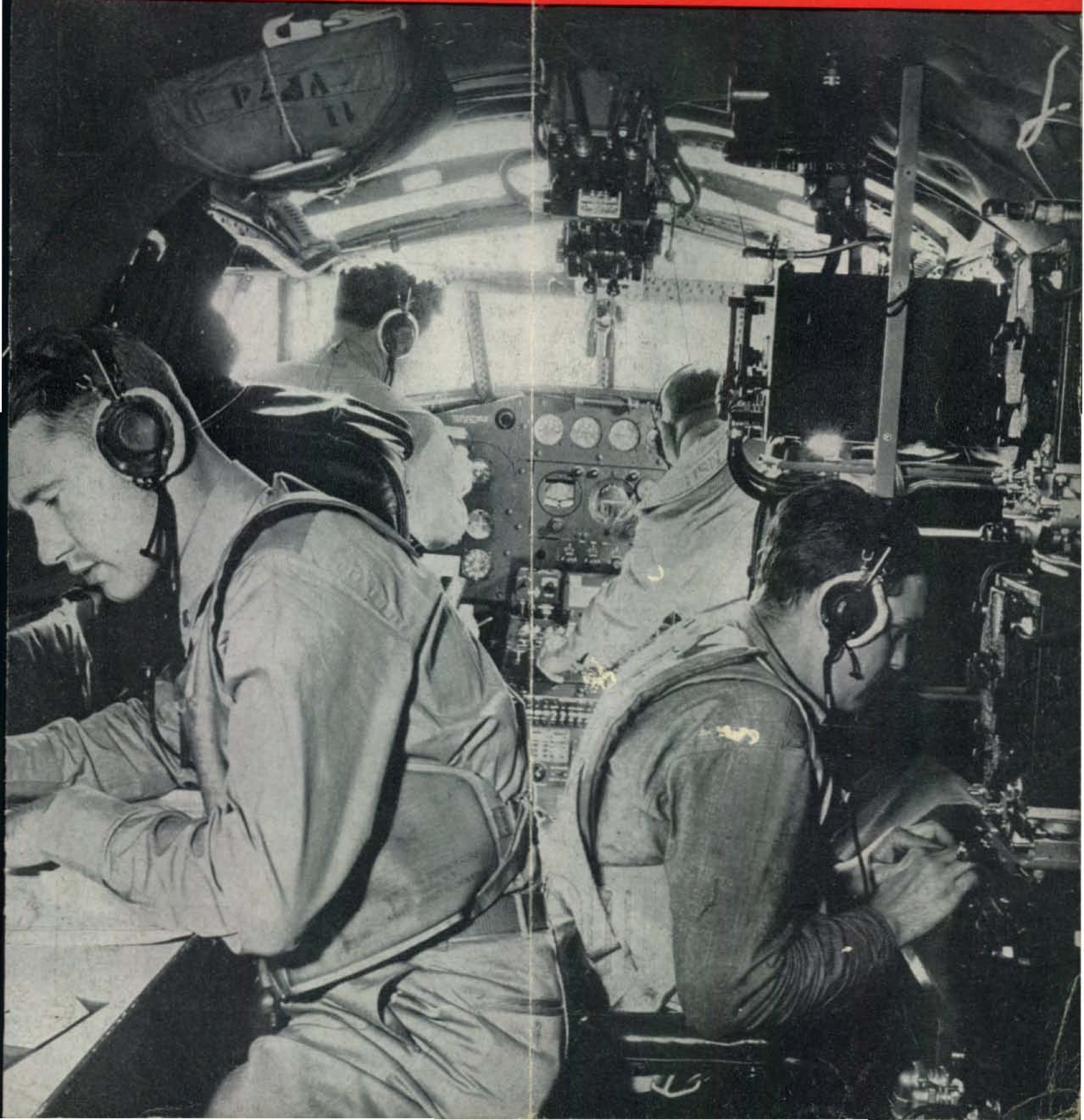

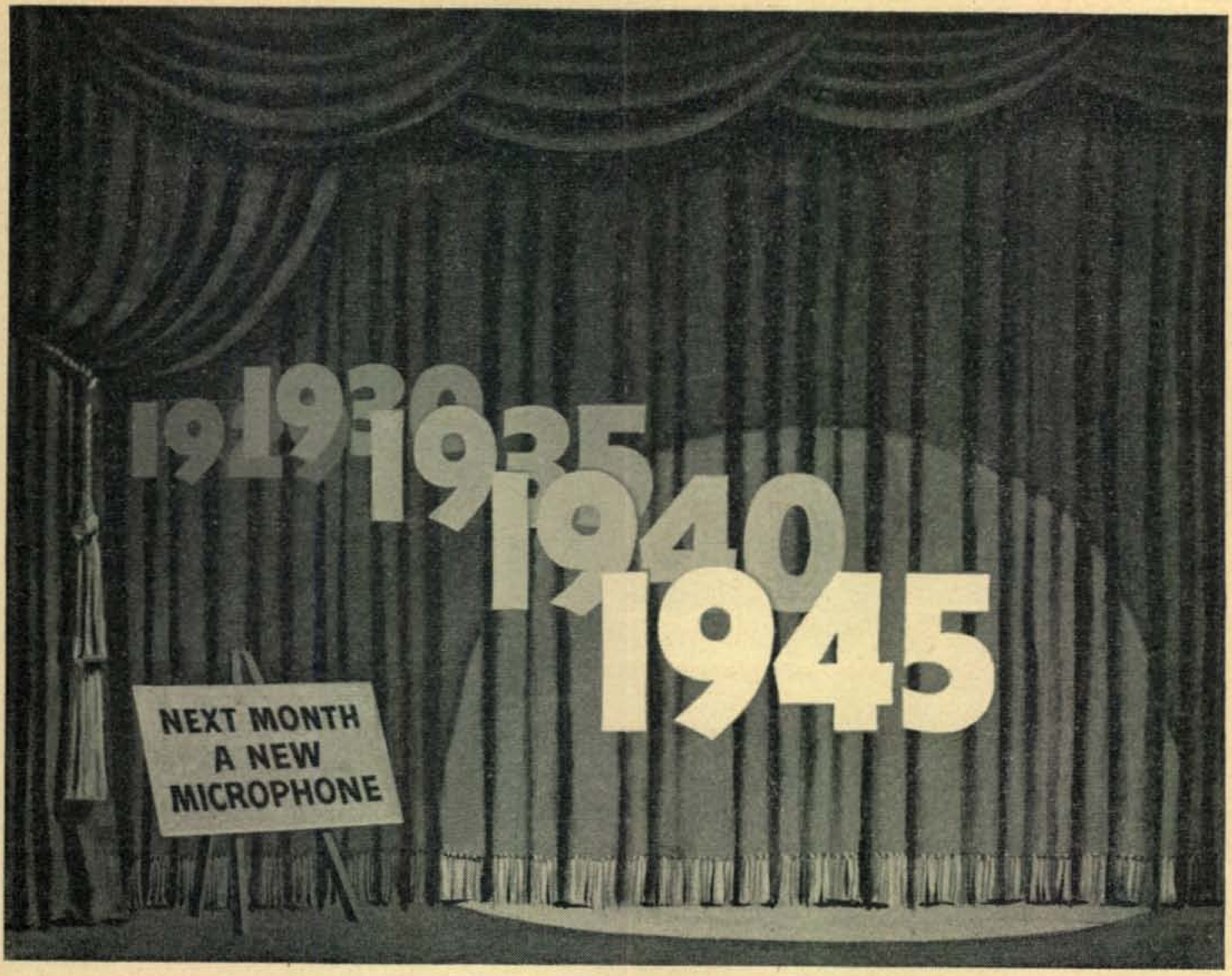

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Published by RADIO MAGAZINES, INC.

John H. Potts. . . . . Editor
Sanford R. Cowan. . . . . Publisher

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VOL. 1, No. 3 **MARCH, 1945**

CONTENTS

COVER

Interior of PBM (Martin Patrol Bomber). The radio operator is shown at the right—*U. S. Navy photo.*

ARTICLES

MISCELLANEOUS

ZERO BIAS

Green Light to Hams by FCC

Printers ink was still moist on last month's editorial when the FCC, in announcing allocation above 25 megacycles, reaffirmed its faith in the radio amateur by pledging the following post-war bands:

28 to 30 megacycles
50 to 54 megacycles
144 to 148 megacycles
220 to 225 megacycles
420 to 450 megacycles
1125 to 1225 megacycles
2500 to 2700 megacycles
5200 to 5750 megacycles
10,000 to 10,500 megacycles
21,000 to 22,000 megacycles

No allocations for any services have as yet been indicated below 25 megacycles. However, the American ham receives fulsome praise from the FCC for his part in the original development of the short waves and still higher frequencies, for the amateurs' assistance in national emergencies and for their current contributions to the war effort. All this augurs well for the ham, and it is more than likely that most of the old rigs, after V-E and V-J Day, will require little in the way of reconversion other than a good dusting. Television is definitely in the cards.

The FCC's recommendations also substantiate our editorial prophecy that frequencies would be made available for telephonic communication under modified license requirements calling for neither code nor technical knowledge. Such licensing should amount to nothing more than registration. At the present, a "restricted radiotelephone operator permit" can be secured without examination in code or theory, for the operation of certain police, automatic marine and similar equipment. However, a written examination in basic radio law is required which can well be as stiff as a technical check-up. This last prerequisite should and probably will be eliminated, or the questions greatly simplified, in permitting "free-for-all" operation in the "Citizens Radio Service" 460 to 470-megacycle band.

The Ham Angle

The FCC has a somewhat glorified vision of a "walkie-talkie" era in which such equipment will become as common as hip-flasks in prohibition days. While all this may come to pass, our thoughts concerning the easing of license requirements in a limited band remain, as expressed last month, that such permits will offer a sugar-coated introduction into amateur radio. The fact that the FCC will not be concerned with interference between such transmitters contributes further to amateur possibilities. The embryo ham will be permitted to experiment and tinker with his "handie" or "walkie-talkie" or reasonable facsimile thereof—a concession to the experimental urge that finds so abundant expression in amateur radio and which is largely responsible for its existence.

The holder of a restricted radiotelephone operator license is *not* permitted to make any adjustments in his equipment—mainly with the consideration that inexpert essays at servicing might result in non-operation or interference with other stations in the same service. Operators in the Citizens Radio Service will apparently not be restricted in this respect, and the screwdriver inquisitiveness of many individuals (plus the fascination of distant communication without wires) should often result in more formal investigations concerning what

[*Continued on page 38*]

Youth and Experience — That's one combination that enables Meissner "precision-el" to produce the quality electronic equipment for which Mt. Carmel is gaining national recognition, for skill in electronics is rapidly becoming a tradition in this little city on the banks of the Wabash.

"PRECISION-EL"

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No part is too small to merit the concentration and precision workmanship that characterizes Meissner precision-built products. Here a member of Meissner's "precision-el" shows why the name is so well deserved by the men and women of Meissner.

"Step Up" Old Receivers!

These Meissner Ferrocart I. F. input and output transformers are getting top results in stepping up performance of old worn receivers. Special powdered iron core permits higher "Q" with a resultant increase in selectivity and gain, now available for frequency range 127-206. Ask for numbers 16-5728 input, 16-5730 output. List $2.20 each.

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42-ton Boeing Clipper which carries two Flight Radio Officers among its twelve man crew. (Photo PAA)

FLIGHT RADIO OFFICER

A POST-WAR OPPORTUNITY FOR HAMS

L. LeKASHMAN, W2IOP

Combine two of the most fascinating fields in the world, flying and radio, throw in a dash of travel with a sprinkling of foreign lands and you have some ingredients of a profession offered in the post-war expansion of air commerce. While radio operators, apart from pilots holding restricted licensese, have been employed on planes from the early Pan American days, our war-expanded transport system has emphasized a hundred-fold the importance of this full-time radio job. And the duties of the FRO are considerably more than mere operating.

THE radio amateur who found, in the armed services, that his hobby gave him a special advantage over a newly trained radioman, will probably be wondering if the reverse will hold true for post-war jobs in the radio field. The answer is an emphatic yes! The idea of earning a living at radio, for many pre-war hams, is a result of their further training in military service. While the war isn't over, no one can doubt the wisdom of looking ahead. One occupation that is not widely discussed because of the relatively few men engaged in performing it until the war, is that of Flight Radio Officer.

If ever a natural opportunity awaited the man who likes to combine a technical "know-how" with operating, ample responsibility, a chance for personal initiative, *and* a good living . . . this is it! The post-war airlines will be expanding. Let's get acquainted with the communications experts in the multi-engine aircraft that have opened the new flying age.

Specialized Crew

There is at least one Flight Radio Officer on the crew of every commercial flight overseas. The complex duties of flying have been departmentalized to a considerable degree. The operation and responsibility have been delegated to specialists in flying, navigation, radio, and engineering. The man handling radio is more than an operator. The title FRO is given, not in an attempt to put on a "front," but because there is a definite line of demarcation between his duties and those of a flight radio operator. All the radio and electronic devices, plus radio navigation, are under the supervision of the Flight Radio Officer. Actual communications is only a nominal part of his work. There is seldom an idle minute in flight. On the ground, training programs, detailed reports, and advanced checkouts effectively fill time not scheduled off.

High Qualifications

The airline requirements are rigid because only the finest type of man can meet the exacting requirements of the position. Besides the technical excellency, there is the important consideration of passenger relations. Crew members are constantly coming in contact with passengers. On some of the larger aircraft of the future this may not be quite so true as it is today. Nevertheless the most priceless asset of any airline is its personnel. Every man must be considered as an investment; which is one reason why it is tough to get in, but once you are, the job offers security. Physical condition is important, but men qualified for military service will have little trouble on that point.

Remuneration is at a point where it is difficult to discuss wage scales with any sort of authority. The biggest objection to the work has been that the pay was inadequate. Both the airlines and men have had the question under discussion for some time. A number of agreements have been signed which have greatly improved conditions. Among existing contracts, available for public inspection, the top salary indicated is $475 a month. An average, between the starting wage of $250 and the top is approximately $325 per month. Since no bonuses are paid, as in the merchant marine, these figures are final. By war-time standards they are not too high, but in normal days the compensation is adequate and far above the average American income. It is to be expected that increased duties on new planes will contribute additional pay increases.

The appearance of labor organizations has resulted in written contracts for the first time, which have established definite standards for the profession. Up until the war the small size of the airlines permitted labor relations to be on a personal basis. This is impossible today. In all these dealings, relations between the companies and unions have indicated an understanding and unanimity of purpose insuring that high standards in the profession will be maintained.

Operational Periods

Of course, like all good things, there are some points on the unfavorable side of the ledger. The home life of the Flight Radio Officer is far from ideal. His hours are irregular and the length of flights varies from a few days to several weeks. But aside from these extended absences from home and the unpredictable hours there is little complaint. When a man retires from active flying because of age or health, he will, at the present wage set-up, suffer a cut in salary. But as the industry becomes more stable the longevity of the job becomes greater. Likewise, more benefits are being negotiated for, to ease the transition from flying to a less active life. Because of the large communications departments of airlines it is doubtful if qualified flight men will ever have any concern about employment.

Flight hours average about one thousand a year. A certain length of time off is given after each trip, based on the number of hours accumulated. This varies with airlines, but is seldom less than a day off for every 10 hours in the air. In addition, annual leave of 30 days is the customary vacation for flight personnel. All living expenses are paid while on flight outside of the home base, which practically amounts to higher wages. The CAA has established definite regulations concerning the number of hours a crew may fly before resting. This, combined with the airlines constant care in protecting the health of crewmen, assures adequate rest periods.

License Requirements

Before a man is qualified to take flight radio training he must hold an FCC license. The commercial second class telegraph ticket will not be difficult for the experienced ham. While the knowledge of radio theory and code proficiency goes beyond the amateur requirements, the fundamentals haven't changed. Holding the radiotelephone first class license will eliminate the necessity of obtaining it later, while serving as an additional recommendation.

After obtaining the licenses and being hired by an airline, the real work begins. Flight communications is a far cry from turning on a transmitter and automatically getting proper results. The selection of frequencies, ability to stay in contact under adverse atmospheric conditions, and, if necessary, the repair of airborne equipment, is required of a fully qualified FRO. Passenger and crew safety is the primary consideration in maintaining regular communications with a base control station. The exchange of nothing more than an identification signal at fixed intervals, indicates the aproximate position of a plane if a proper flight watch is kept. If an aircraft is not heard from for some pre-determined number of these intervals, an emergency plan is set into operation.

During normal flights there are weather amendments, terminal and alternate weather conditions, and the transmission by the aircraft of the latest spot-weather to various bases to facilitate accurate flight forecasts. Position reports are transmitted to assist the flight watch in plotting the progress of the plant. In addition there are routine requests for passenger service; also, for maximum efficiency in aircraft operation, maintenance problems in so far as practical should be fully anticipated and transmitted before arrivals, allowing the ground organization to prepare in advance.

FRO Training

Most airlines have an extensive training program—since even a well trained radioman must be thoroughly acquainted with the special requirements of aviation radio. During the apprentice period, training is given in flight equipment, radio navigation, first aid, routes flown and in a multitude of details which, while seemingly unimportant, add up to efficient and safe flying. The aldice lamp for visual communications, emergency drills, life saving, meteorology, passenger relations, codes, customs, and regulations, are all on the training agenda. The CAA has announced plans to license Flight Radio Officers after the war. This will mean it may be necessary to hold certificates from both the FCC and CAA to qualify as an FRO. In the event that the Civil Aeronautics Administration certification actually goes into effect immediately upon resumption of full-scale commercial flying, it is certain that the airlines will train their men to meet the requirements of the new license. In formulating the qualifications, the CAA is consulting everyone in the flight radio field, with the result that the examination will be largely practical knowledge which can only be gained with experience and highly specialized schooling.

Navigation

Radio navigation is a primary duty of the Flight Radio Officer, which is constantly growing in importance as new inventions in the field are released. Today, experienced celestial navigators rely heavily upon radio as an aid. On many operational and passenger flights, radio has been able to replace the sextant and tables.

On long overseas flights, or in localities where traffic does not warrant the erection of ranges and markers, other facilities are now available. Operation of the radio loop for bearings and ground DF station utilization are part of the FRO's work. Fixes, track and speed bearings, and lines of position may be taken with a high degree of accuracy with an aircraft loop. All of these aids combined, point the way to a new era in air navigation. Secret devices, such as radar, will of course alter the complexion of things, but it is certain that the Flight Radio Officer will be in charge of them. The eventual outcome of the new and secret radio navigation facilities may be multiple-crew planes carrying a radio-navigator, who will also be checked out in celestial navigation. Thus, radio will become the primary navigation tool and celestial the aid.

Probably the most difficult thing for the new radioman to grasp is the ability to

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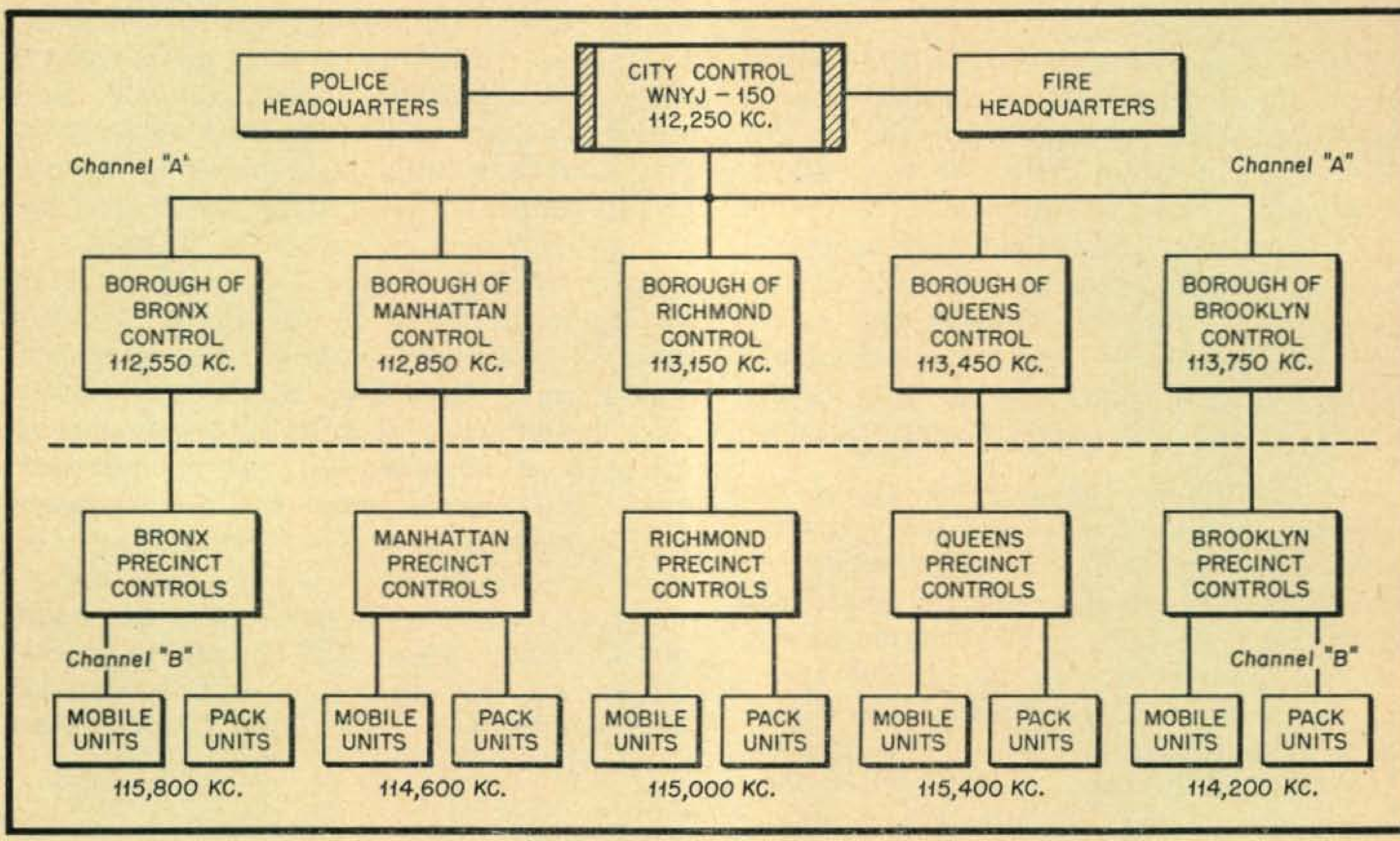


Fig. 1. War Emergency Radio Service (WERS) set-up for Greater New York City

WERS at work

. . . with no let-down among the 300 units of this war emergency organization

VINCENT T. KENNEY, W2BGO*

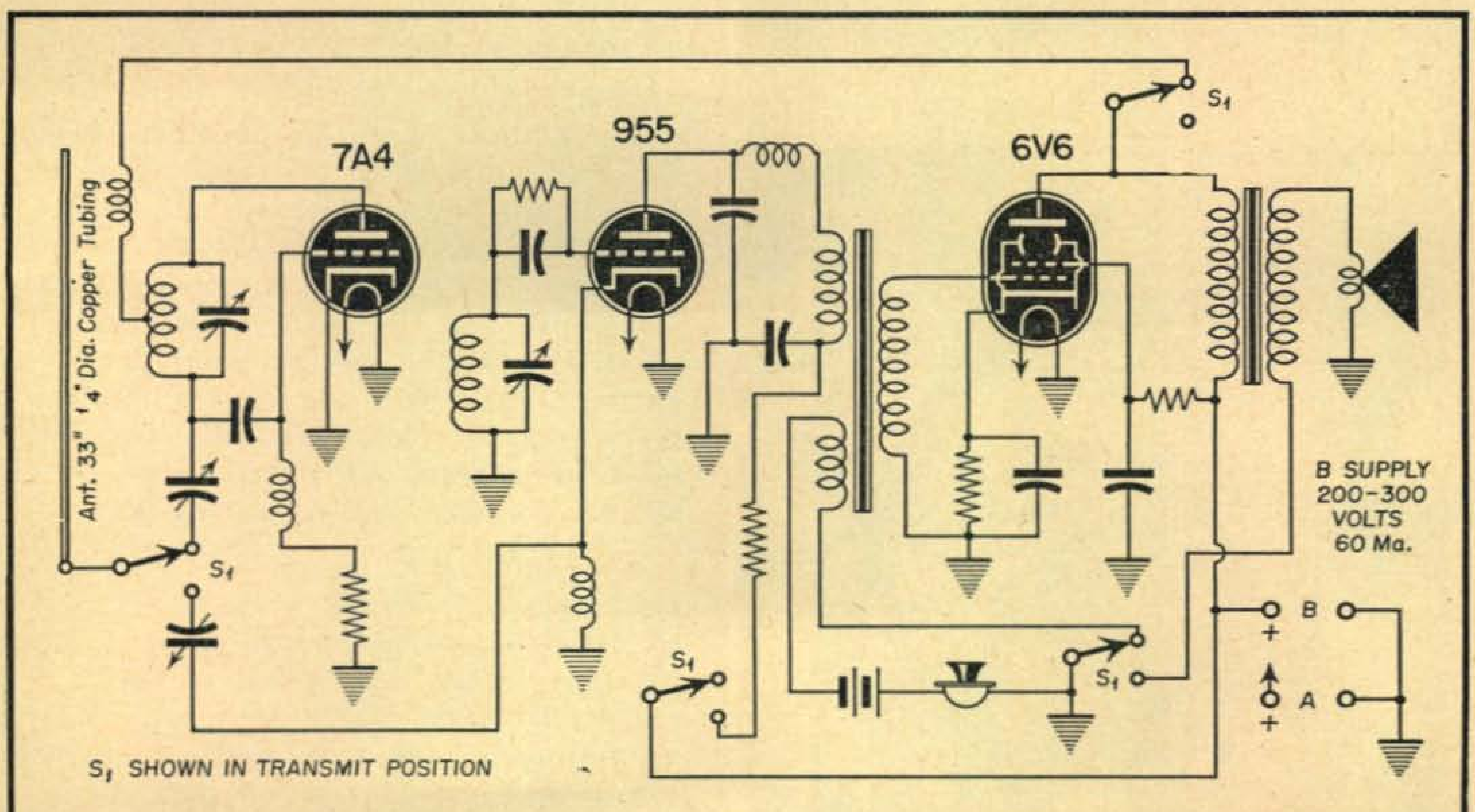
AMATEUR radio operators who formed the nucleus of the War Emergency Radio Service know what an important part communications plays in virtually every disaster. Therefore, with this understanding, the hams are working harder, rather than letting down. The WERS has by no means suffered as a result of the apparent relaxation of civilian defense activities. More and more individual stations are being added to original lists, such as in New York City. In September, 1942, 33 units and 38 operators were licensed. February 1945, two and a half years later, adds up to 323 units and 592 operators!

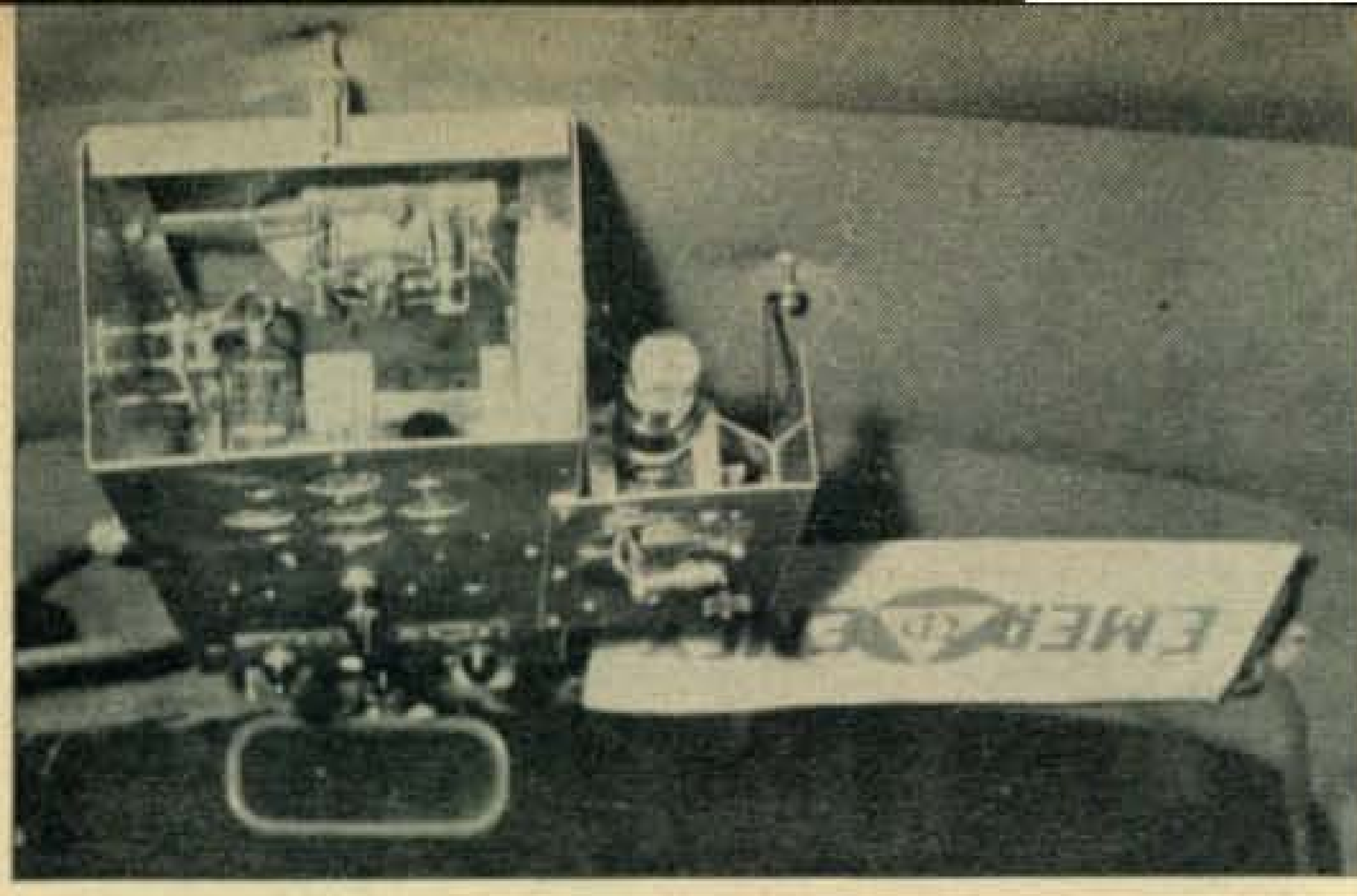
Typical of hams, a rig that operates well is not good enough. Improvements are constantly being made, which not only contributes enhanced efficiency to the service rendered, but keeps the ham satisfied with the knowledge that progress has been achieved. Constant changes in equipment are a good indication of the interest in this civilian defense activity.

Civilian Defense Station WNYJ of the

* *Radio Aide for the City of New York. ARRL Regioal Co-ordinator New York City.*

Fig. 5 (above). View of City Control, WNYJ-150, showing the main transmitter at the left; the main receiver, an AM-FM superhet, in front of the Radio Aide speaking into the mike; WNYJ-280 is in front of Chief Electrician E. Lussier. A third receiver is on a third table to the left of WNYJ-150 (not in photo). Below, schematic of transmitter-receiver





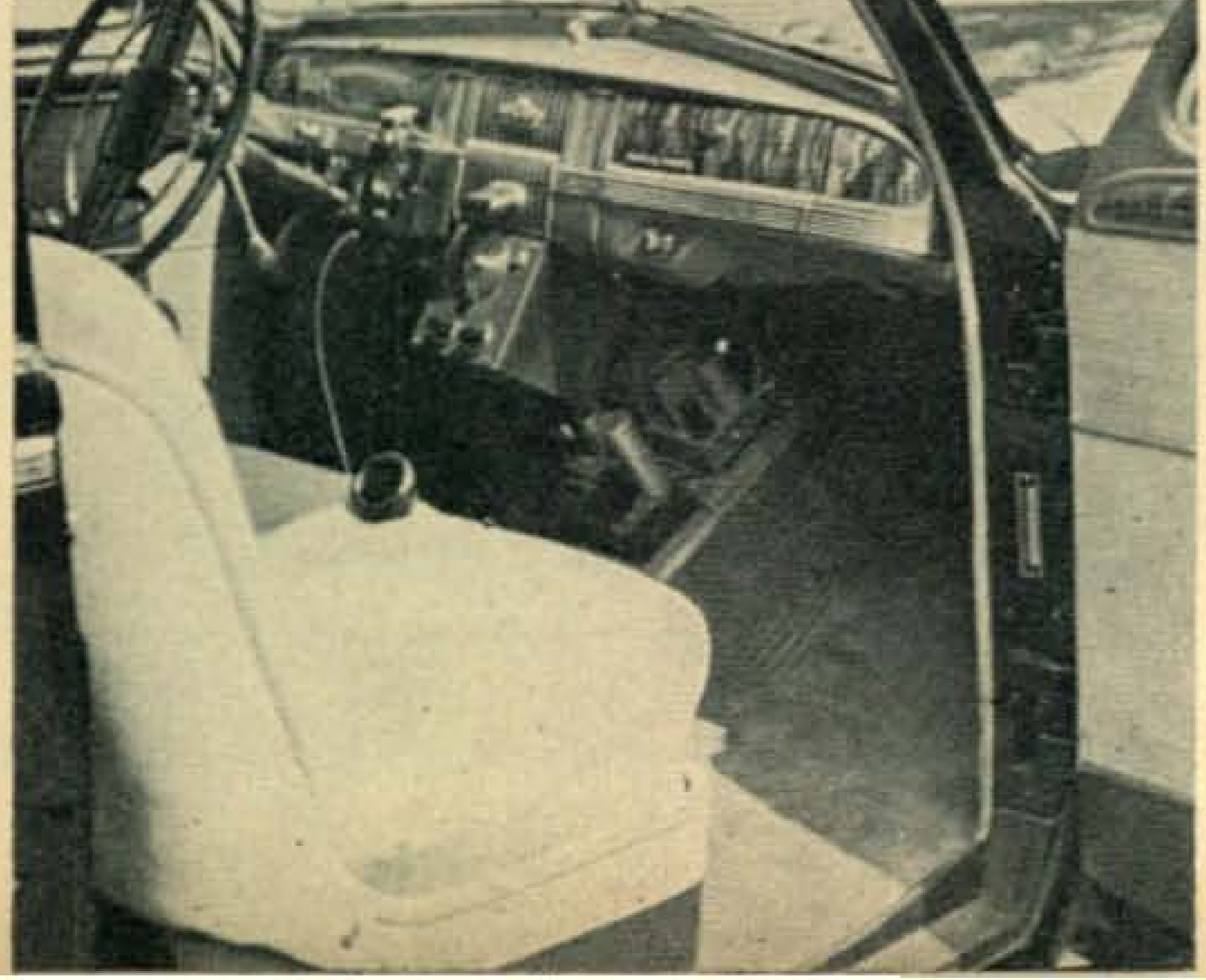


Fig. 3 (top). WYNJ-300 viewed from the floor of the car from the driver's side of the front seat.

Fig. 2 (middle). WNYJ-300, fastened to the under side of the roof of the car, looking at the transmitter and receiver from the rear of the car. The rear-view mirror is seen under the transmitter.

Fig. 4 (bottom). WNYJ-58, one of more than 100 mobile units in New York City's WERS. This is typical of most mobile units.

City of New York is undoubtedly the only WERS system of its kind in the country. The area covered by this license is 320 square miles in which 7,500,000 people reside in five separate boroughs or counties. This population increases and decreases continuously, peaks being noted during business hours, with 30 to 40 percent increases. Like Manhattan, the business center of the city, the population of the other four boroughs changes hourly.

In the territory covered by WNYJ, the WERS system must of necessity parallel normal police, fire, and medical communications lines. Units are installed in almost all police stations, fire alarm headquarters in each borough, and in many of the city's hospitals. As these vital services operate more or less independently in each borough, a WERS net with its own control unit operates as one net of the whole city system, there being six separate nets. The sixth comprises the City Control unit, one at the District Warning Center, one at a city-wide control point, where operation of all protective forces is coordinated, and the five borough control units.

The plan of operation of WNYJ remains the same today as originally conceived. Each of the borough control units is crystal controlled, and a glance at *Fig. 1* shows 300 kilocycles separation between stations. For convenience sake, a control unit's frequency is known as Channel A in each borough net. This not only minimizes interference, but allows neighboring WERS nets to operate on frequencies between WNYJ controls and be in the clear.

The same plan is in use for borough nets, except that this work is not confined to crystal control operation. As borough nets are in the upper half of the 112-116 megacycle band where frequency stability requirements are less rigid than in the lower half, all types of equipment are used.

Varied Equipment

Equipment in use is of three types, fixed, mobile, and pack, with approximately 100 of each type. The units operating in any given borough operate on a spot frequency. These borough frequencies, beginning at 114.2 megacycles and separated by 400 kilocycles, permit five channels, as outlined in *Fig. 1*, each known as Channel *B* in its respective borough.

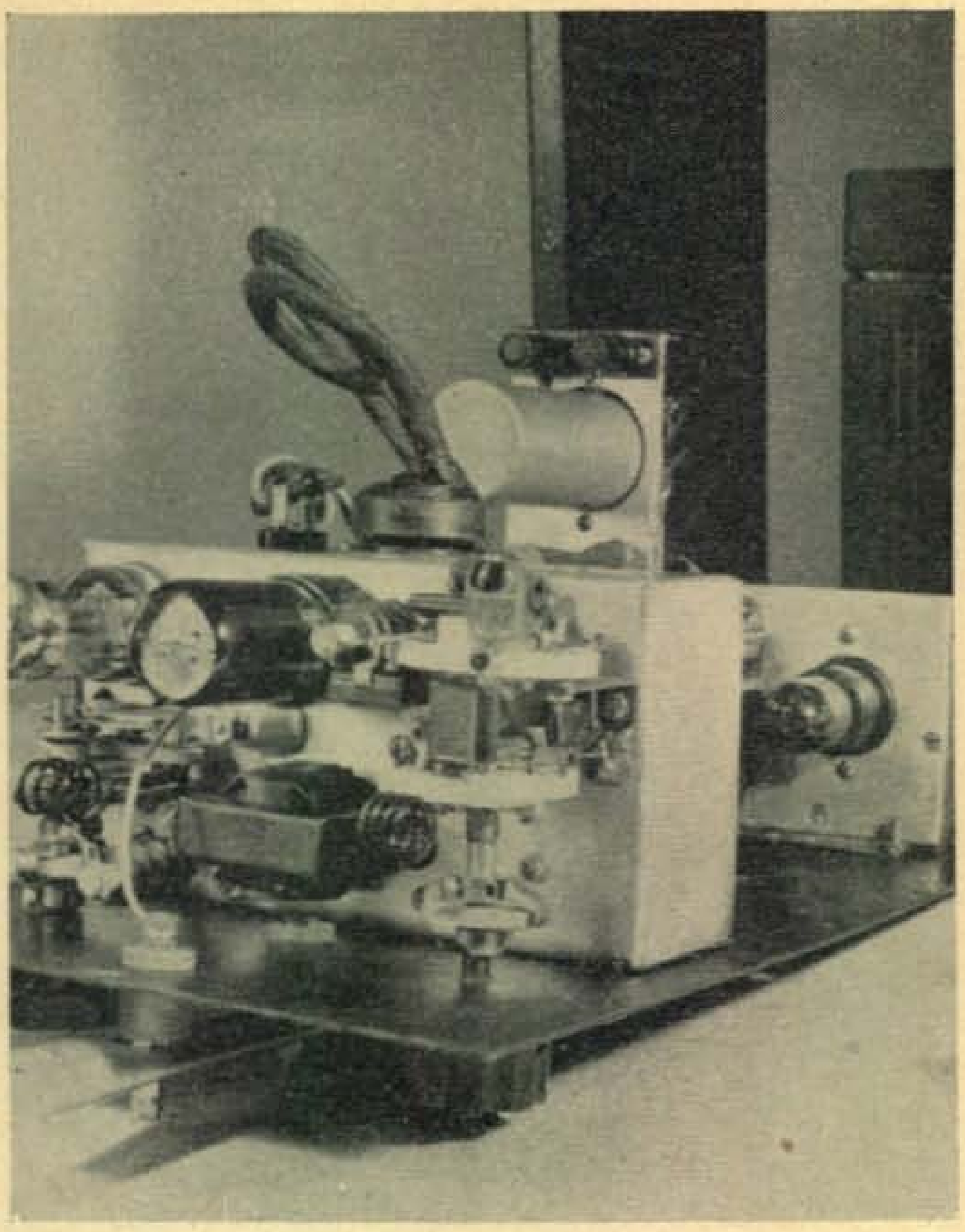
At each borough control unit location, a second transmitter is installed, tuned to the borough frequency, or Channel *B*, and used for the purpose of calling any unit in its net. It is used only for calling a station. Once contact has been established, the net control instructs the unit called to listen on Channel *A*, where Borough Control is transmitting. Thus, approximately 50 percent of what would require continuous time with two units communicating with each other on one frequency is saved in cross-band operation.

Borough nets are broken down into subdivisions of precincts, each precinct having a control station. Pack (walkie-talkie and handie-talkie) and mobile units are assigned to precincts and report to the precinct control. Thus a borough control station is always informed as to the location of mobile and pack sets within its borough.

Two receivers at each borough control location do all that is necessary, one being tuned to the City Control frequency and the other to the channel on which the units in its borough operate. At City Control a somewhat different arrangement is necessary, since six channels must be monitored. Three super-het receivers are employed with as many operators in attendance. One receiver monitors units in the City Net and Bronx Control; a second tunes to Manhattan and Richmond Control channels, and a third watches Controls of Queens and Brooklyn.

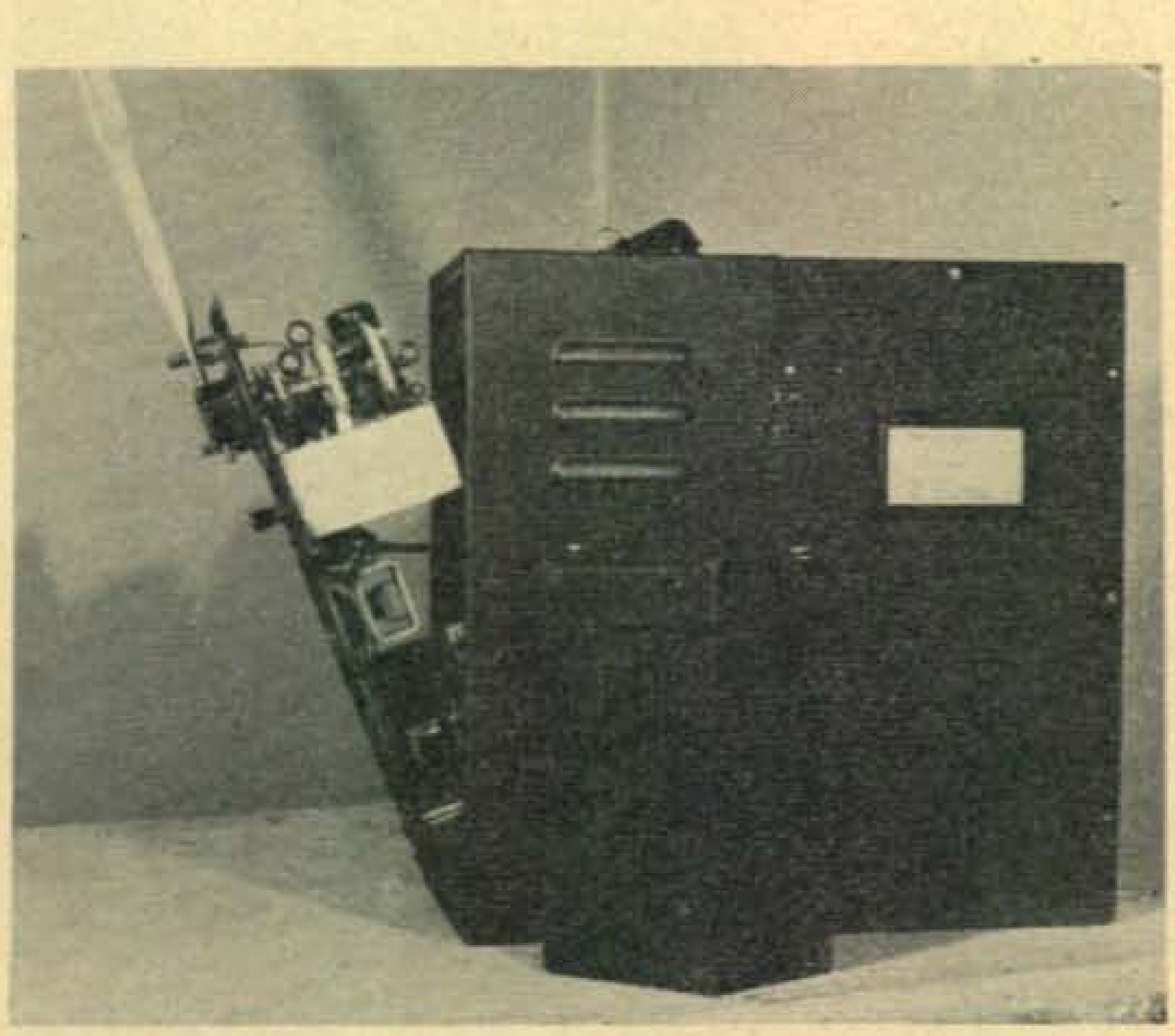
Mobile Units

One of the mobile units included under WNYJ's license is WNYJ-300. *(Figs. 2 and 3)*. This transmitter-receiver is mounted to the right over the driver-operator's head and is attached to the under side of the car roof. Within easy reach of the operator's hand at all times, it is well protected from the weather and in such a position that it will not be easily bumped against. This arrangement minimizes the length of feeders, for the antenna is only a few inches from the transmitter. A push-to-talk arrangement in the microphone controls the antenna relay. The power supply is mounted between the car heater and the broadcast receiver under the dash.

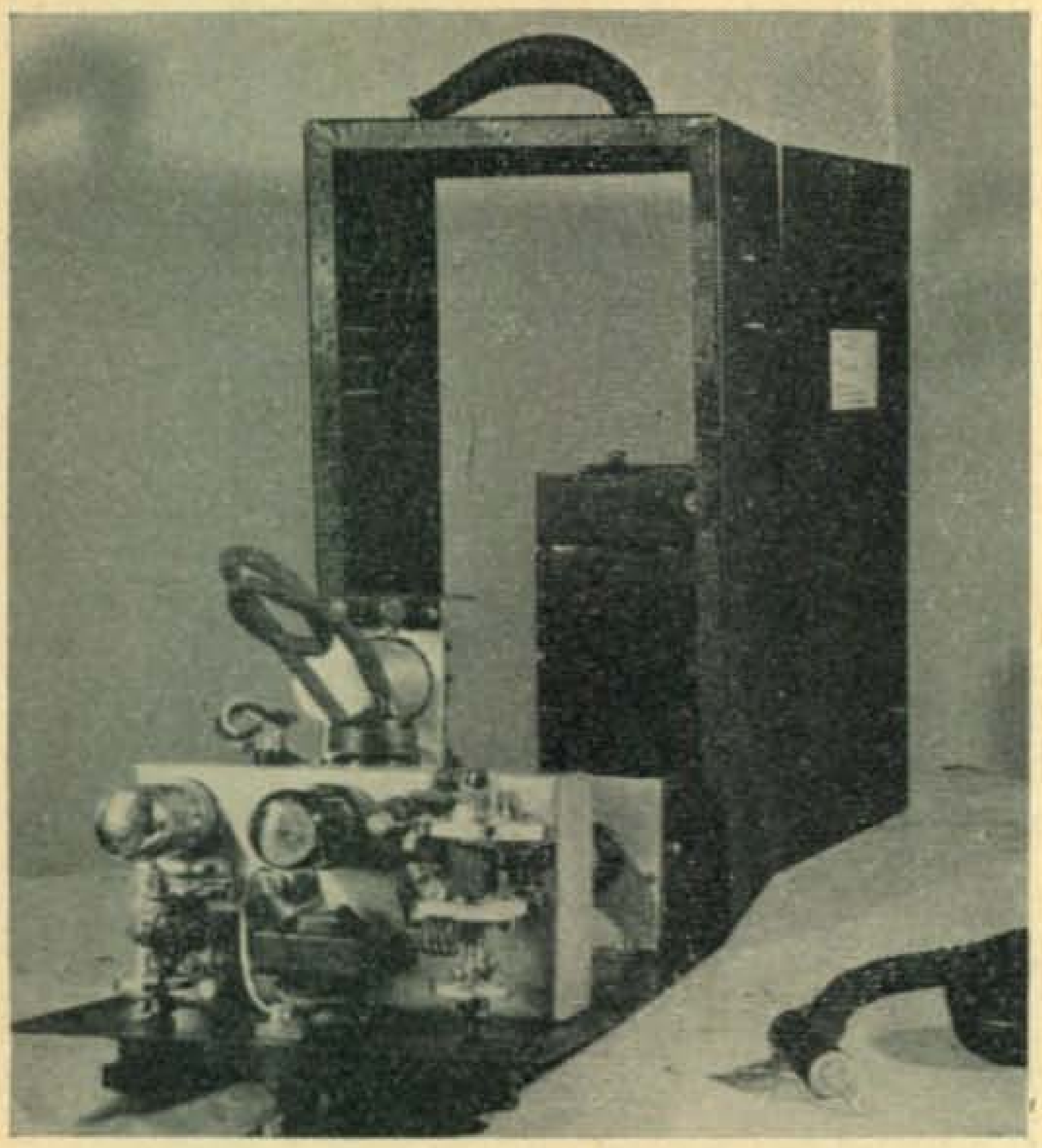


Transmitter-receiver chassis

WNYJ-58 is an MRT-3 of pre-war days. To the right of the steering column *(Fig. 4)* is a unit including a master switch and plate milliampere meter. Below can be seen the receiver, with the power supply directly beneath. The transmitter is to the



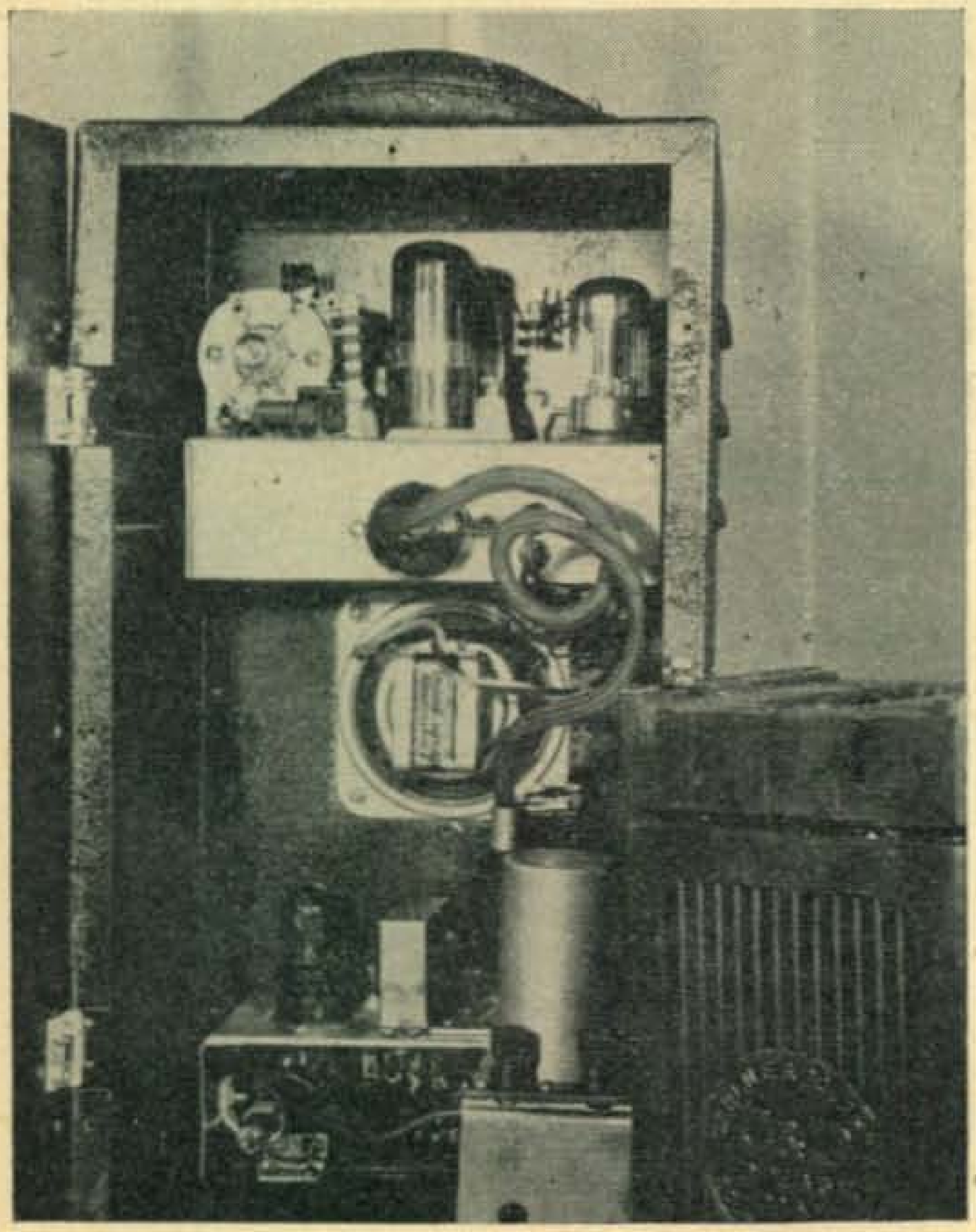
Side view of transmitter-receiver



Top view of transmitter-receiver chassis.

left of the steering column out of sight. The antenna can be seen through the windshield and is a half wave arrangement fed by coaxial cable. A push-to-talk microphone is also used in this unit.

Rear view of chassis.



City Control Station

The City Control station, WNYJ-150 *(Fig. 5)*, located high in one of New York City's tallest buildings, can contact direct almost any unit in the entire city, including several pack sets. WNYJ-280 is a duplicate of WNYJ-150, installed alongside of the latter. Two switches puts 280 on the air within a few seconds of a breakdown of the city control transmitter. Power for these units, as well as for the three receivers, is obtained from a 1-kilowatt motor-generator, the original source of d-c current being generated in the building.

A unique mobile station is WNYJ-181, constructed in such a manner that the unit, including transmitter, receiver, power supply, storage battery, battery charger, and antenna are mounted on an improvised two-wheel truck. This unit is operated in or out of a car and where AC current is available is not dependent upon its battery. Push-to-talk operation is another feature of WNYJ-181. Similarly, several pack sets are also designed for battery or a-c operation.

Some handie-talkies with strong signals are energized by small storage batteries of the motorcycle type. These batteries will give from three to eight hours continuous service, depending upon the drain. Operators of these units have equipped them with two such batteries to insure a fully-charged battery on hand at all times.

When an "alert" is sounded, operators assigned to locations of fixed stations proceed to their posts, put their units in operation, and sign into their borough net announcing the unit ready for operation. Mobile and pack set operators take their posts at pre-arranged points within their precincts (as close to their home as possible) and report into the precinct nets, whereupon they are instructed to stand by.

During practice alerts and blackouts in the past, the only signals here were stations reporting into their nets. Once this is completed, a matter of 15 to 20 minutes after the first blast of the sirens, all operators intently listen for instructions from their control units. Immediately upon receipt of the "all clear" signal, roll is called, after which each borough control unit transmits a full report of units in operation and the number of operators participating to the City Control. This procedure is followed in any emergency.

High Gain
112-MC BEAM ANTENNA

ROBERT Y. CHAPMAN, W1QV

Economy and Simplicity of Construction Are Features of This Directional Radiator

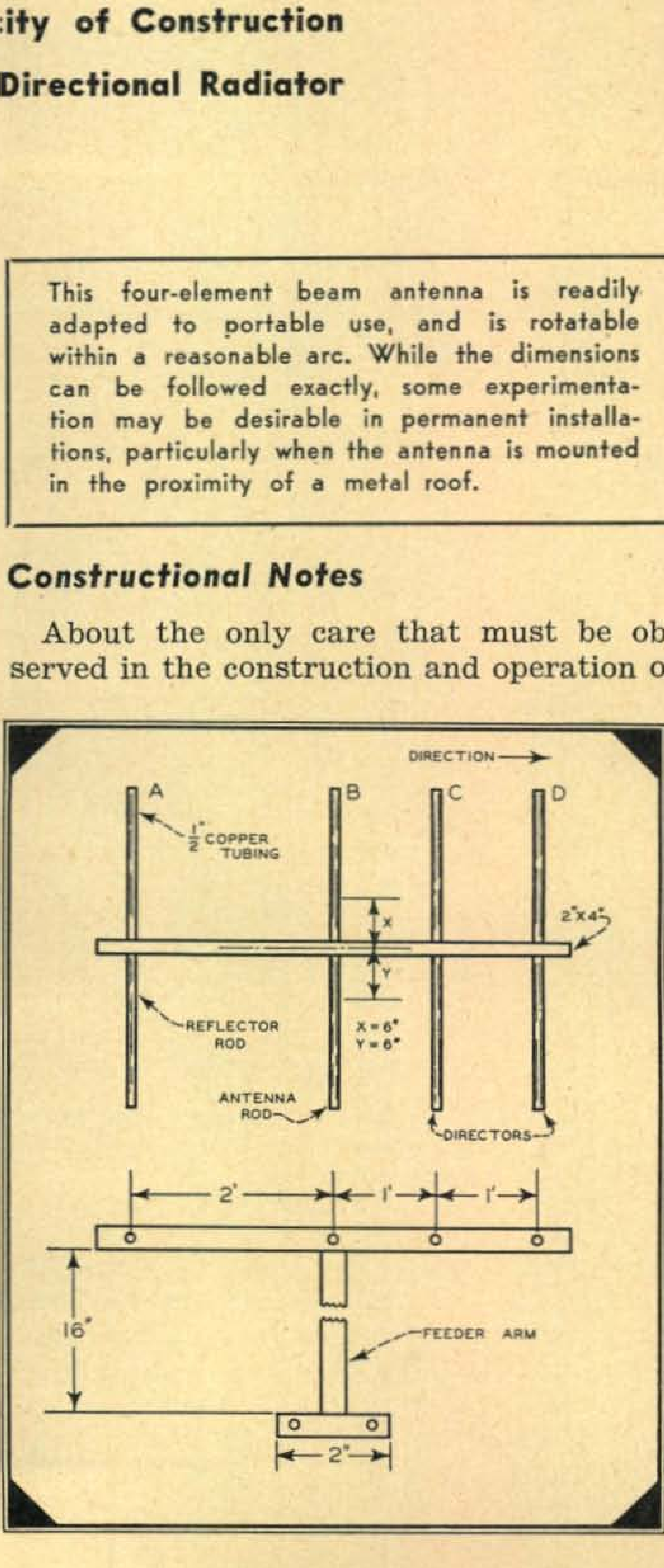
THE type of beam described and illustrated is probably the most popular used by the "dx" boys on the 112-megacycle band. It offers many advantages—electrical and mechanical. As will be observed from the sketches, *Fig. 1, 2* and *3*, it can readily be adapted for permanent installation or portable operation. Dressed 2 x 4 lumber is generally used when the antenna is going to stay put, while lighter material is employed by the boys who tote it around. In the portable job, the holes in the main arm are drilled just slightly larger than necessary to pass the ½-inch copper-tube elements. Small holes (about ¼-inch) are drilled in the elements, just above the half-length mark, and wooden pegs inserted to prevent the elements from slipping through the holes in the support. Clips are used to attach the feed line to the off-center position on the radiator element. This antenna system can be erected in a very few minutes on any convenient base, such as a fence post, and will be found far more effective than a car antenna. The time and effort are well worth while.

Figs. 1 and 2. Main constructional details. The elements are of one-half inch copper tubing. Element A is 51" long, B 49", and C and D 46" long. Leads to feeders connect to element B 6" each side of center. You can use "dressed 2 by 4s." On a portable job drill holes for elements slightly larger than tubing. Wooden pegs in tubing, just above center, keep elements from slipping through

This four-element beam antenna is readily adapted to portable use, and is rotatable within a reasonable arc. While the dimensions can be followed exactly, some experimentation may be desirable in permanent installations, particularly when the antenna is mounted in the proximity of a metal roof.

Constructional Notes

About the only care that must be observed in the construction and operation of



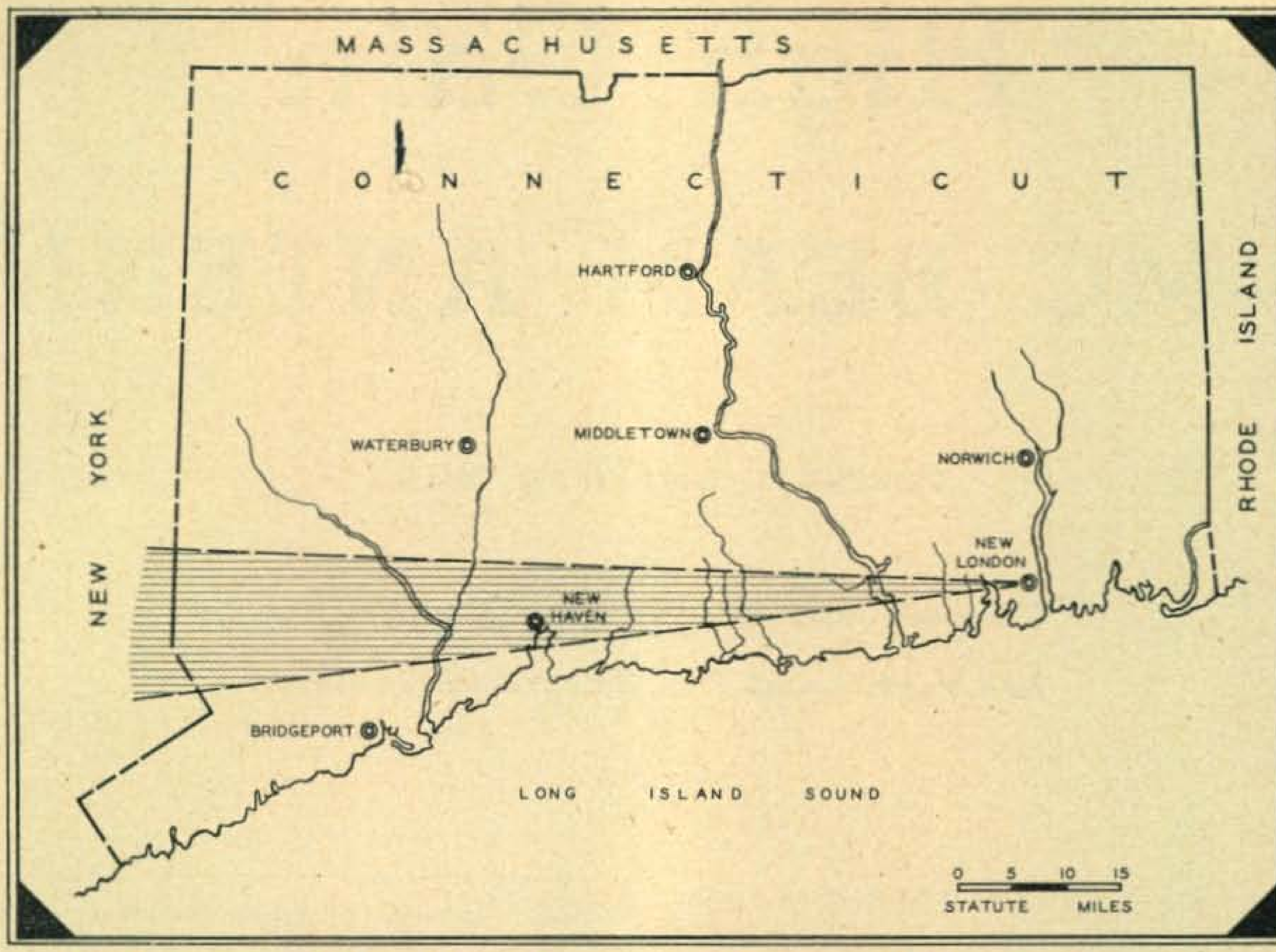


Fig. 4. A general idea of the sharpness of the beam. This is not, of course, a true field strength pattern. Both concentration and cut-off are very pronounced

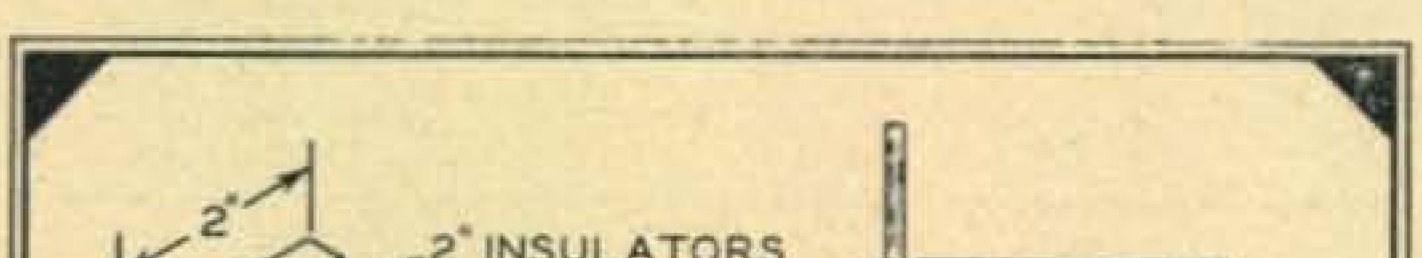


Fig. 3. Details of feeder arrangement. The space between the 2-inch feeder spreaders should not be more than 24 inches

this type antenna is the space between the radiator and the first bend in the feeders. This must be a minimum of 20 inches which can be readily obtained by attaching a light arm or stay to the main antenna support. The feed line should be carefully spaced, with spreaders not more than two feet apart. Number 12 wires, spaced two inches, provide a good match to the antenna.

Results

We have worked over seventy miles with this antenna, and when comparison was made with the usual vertical installation, the difference was so great that the single vertical pole was discarded on the spot! The map of the State of Connecticut *(Fig. 5)* will give a rough idea of the effectiveness of this beam. This pattern is drawn from actual transmission and reception tests over a period of three years, and represent the concensus of the boys who are using the antenna day and night in WERS work.

Excellent bearings can be taken on local and distant stations. Our objectives, high gain, runs about 6 db, and in operation the results are impressive. The writer has experimented with additional directors and reflectors, but has always returned to this number of elements. Considering ham requirements, it is probably better not to make the beam too narrow for general communications.

Last but not least, this antenna is for vertical polarization, and hence should be mounted vertically.

QRB? QTE?

W. H. ANDERSON, VE3AAZ

Trans-Canadian Airlines, Moncton, N. B.

Radio Distance and Direction May Not Be What They Seem On the Map . . . This Article Tells How to Find True Bearings

THE questions of distance and direction are uppermost in the considerations of DX-minded hams. Unfortunately, the great-circle maps, distance tables, etc. on the market do not provide all the answers. One prerequisite to a proper understanding of these problems is to have a good-sized globe on hand. When we try to find the direction and distance from point A to point B on a globe by stretching a string between the points, we find the path of the string to be altogether different from what we had expected after drawing a straight line between these same points on a conventional map. For instance, an ordinary map shows Tokyo to be 6500 miles due west of San Francisco. Actually the distance is only 4800 miles, and if you were beaming an antenna from the Golden Gate, the direction would be approximately northwest! While radio signals do not always follow the shortest route—frequency and time of year are often governing factors—it is obviously important that we know our great-circle distances and directions.

Great-Circle Distances

The string aligns itself along the great-circle route between the points. A great circle is defined as any circle on the surface of a sphere, whose center is the "inner" center of the sphere. For instance, the equator and meridians of longitude are all great circles. An observer stationed at the center of the earth looking out at the two points in question would actually be at the center of the great circle through the points. The portion of the arc lying between the two points would appear to him as a straight line, while all other non-great-circle paths would appear as bent lines, and the straight line would naturally represent the shortest route.

Further observation of the globe will reveal that it is impossible to represent its surface accurately on one plane, such as a sheet of paper. A compromise is the best we can do, such as the Mercator projection generally used in schools, atlases, etc. This is one of the oldest form of maps, but is quite unsuited to great-circle purposes. The reason for this may be seen by noting the meridians of longitude. Mercator has them parallel, whereas on the globe they converge at the poles! This results in extreme distortion of areas and distances in the upper latitudes.

Then there are the great-circle maps centered on a certain point. These maps are visualized from the center of the globe, but here a practical obstacle intervenes. In order to record what is "observed," some point will have to be chosen for a basis of calculations. This is because a map to be

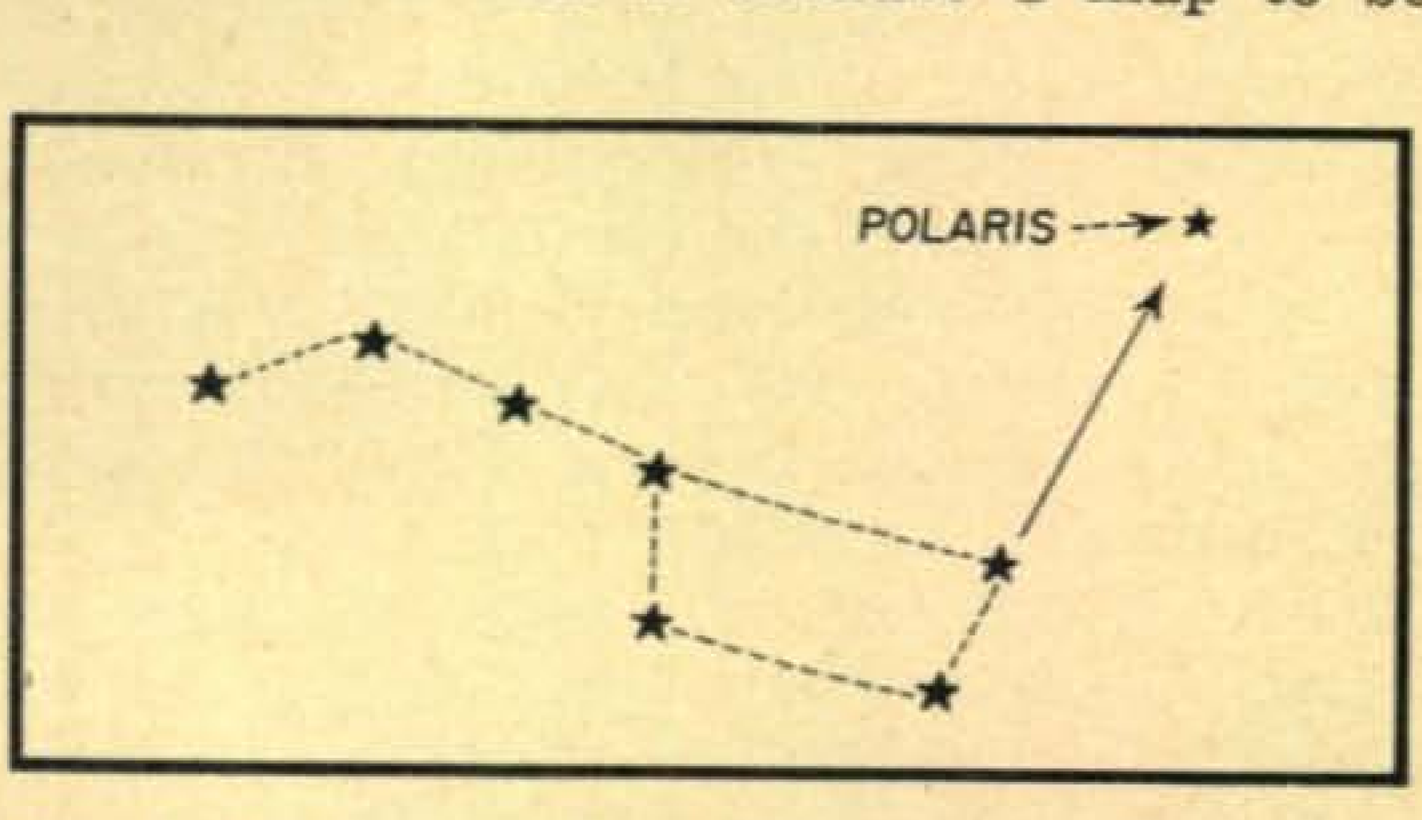


Fig. 1. Position of Polaris with respect to Big Dipper. While Polaris — the North Star, stays "put," the Dipper revolves around it

useful to the average person is laid out so that the top of the map is north, left is west, and so forth. So the observer at the center must "look" outward and place the meridian of longitude in a due vertical position on the map, through the base point. Consequently the other meridians will be neither straight lines nor vertical. That is the reason a "great circle" map centered on New York is of no value for Los Angeles and vice versa, unless you measure all the angles from the curved meridians themselves.

Angle of Departure

The simplest method of obtaining the great-circle direction is to line up the desired points on the globe with a taut string. Note some point on this path that is not over a few hundred miles from the original point, then refer to a conventional map to establish the direction of this point on the line from the starting point. This will give, with fairly close accuracy, the desired "angle of departure," as ordinary maps give reasonably true directions over short distances.

The distance may be calculated by transferring the length of string between the points on the globe, to a position along the equator and multiplying the number of degrees covered by 480/7. For example, should the distance be equal to 55 degrees along the equator, the distance between our points is $55 \times 60 \times 8/7 = 3771$ statute miles. (This follows as one degree on a great circle equals 60 nautical miles and a nautical mile equals 1 1/7 statute miles.)

Which Way Is North?

However, presuming it is known that the great-circle route lies so many degrees east or north or west of south, or whatever it may be, from a great-circle map or other computations, this information is of little value in aiming a directional antenna if true north cannot be established!

Three methods are readily available. Nearly everyone has observed the Big Dipper in the northern skies. Using this constellation (Ursa Major) as a guide, the North Star *(Polaris)* may be identified *(Fig. 1)*, and true north ascertained by sighting up objects or stakes on *Polaris*.

A time-honored method of determining north is to employ a compass. One important point must be remembered in this regard. "True" north refers to the direction of the north pole, but a compass points to the "magnetic" north pole. Unfortunately the poles do not coincide, and the discrepancy so occasioned is termed "magnetic variation." *Fig. 2* shows various values of variation encountered. The importance of the factor of variation may be appreciated by noting that it is twenty degrees easterly in Washington State and about thirty-five degrees westerly in Maine. By this it is meant that in the State of Washington the compass needle points about twenty degrees east of true north, and in Maine it points thirty-five degrees west of true north. So in Washington State in order to have the zero on the compass card pointing to *true* north, (and all other bearings correct), the needle will be over 20° (0° plus 20° variation). On the other hand, in Maine, true north will be at zero on the compass card when the needle is over 325° (360° minus 35° variation). By following the rule of bringing the needle over 360° minus *westerly* variation or 0° plus *easterly* variation, according to *Fig. 2* for the point in question, true north will be indicated by zero on the card.

The Shadow Knows

The most intriguing method of determing true north involves the sun. The old principle that at noon the sun is directly south (in the more northern latitudes) is in need of considerable adjustment in these days of Standard and Daylight-Saving Times. Obviously if the time when the sun was due south could be determined, a shadow cast at that moment would indicate true north. Inasmuch as the earth makes one full journey around the sun every twenty-four hours, it may be said that the sun covers 360/24 or 15 degrees of the earth's circumference per hour. Greenwich time is calculated on the basis that the sun appears directly south of Greenwich, Eng. at 1200 Greenwich time (with certain corrections). Greenwich is at longitude zero degrees. Therefore the time at which the sun will be directly south of any point will be before or after Greenwich noon by a number of hours equal to the Longitude of the point divided by 15. For instance, at Longitude 82° west the sun will be directly south 82/15 or 5 7/15 hours (5 hours and 28 minutes) after Greenwich noon—that is at 17:28 Greenwich time. Standard time,

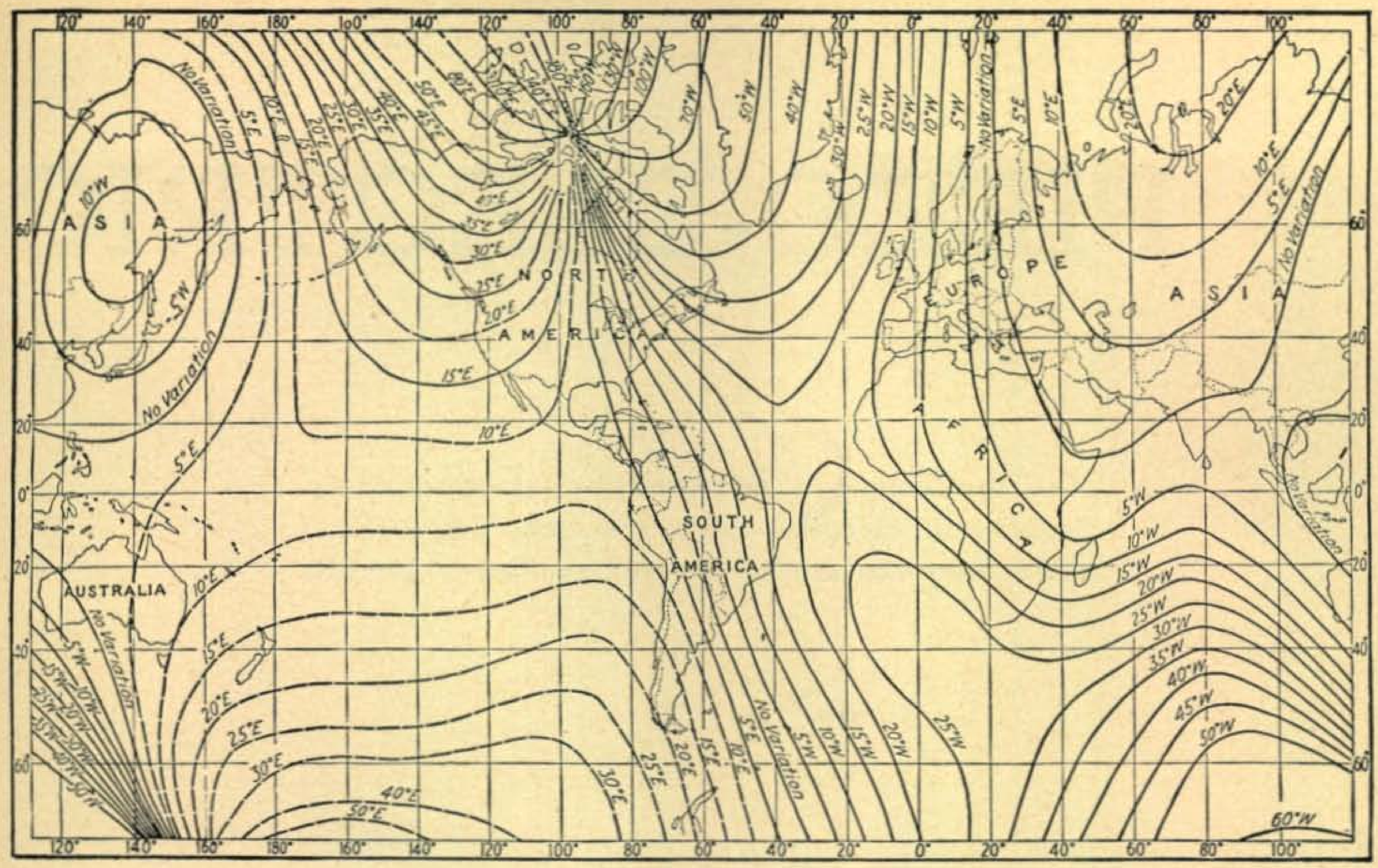


Fig. 2. Your compass doesn't always point north! These are lines of magnetic declination showing variations from "true" north (which isn't the magnetic north, anyway)

From Weems "Aerial Navigaation," courtesy McGraw-Hill Publishing Company.

as observed before the war was four hours behind Greenwich time (GCT or Greenwich Civil Time as it is correctly termed) in the Atlantic Zone, five hours behind GCT in the Eastern Zone, six in Central, seven in Mountain and eight hours in the Pacific Zone. However, with the almost universal advancement of clocks one hour, present Atlantic time is only three hours behind GCT, Eastern four hours behind, and so forth. Returning to the example which is in the Eastern Zone, 17:28 GCT is 12:28 Eastern Standard Time or 13:28 Eastern Daylight or War Time. In other words, the sun crosses the 82 W. meridian at 13:28 Eastern War Time, and at that moment casts a direct north-south shadow.

The Earth Wobbles

A few minutes error, however is introduced by rigid adherence to these rules (by the Earth "wobbling"), and the following table will correct this for all practical purposes. After time has been calculated from the foregoing, during the month of

January, add 9 minutes;
February, add 14 minutes;
March, add 9 minutes;
April, no correction;
May, subtract 3 minutes;
June, no correction;
July, add 5 minutes;
August, add 4 minutes;
September, subtract 5 minutes;
October, subtract 14 minutes;
November, subtract 14 minutes;
December, subtract 5 minutes.

For those interested in the refinements of this procedure, reference should be made to the Nautical or Air Almanacs (obtainable from the Supt. of Documents, Washington, D. C.) for the exact date of the observation. At the moment when the Greenwich Hour Angle (GHA) of the sun is equal to the Longitude of the point, the sun will be directly south of that point. This follows as the GHA is actually the angle between the sun and the meridian through Greenwich.

A small transparent compass "rose," which may be inexpensively obtained at most stationery stores, will greatly facilitate the work of determining directions on maps, also in the field after true north has been established.

PIEZO-ELECTRIC

The fundamentals of crystal-controlled radio-frequency circuits, with practical suggestions regarding the use of crystal oscillator circuits

THE application of the piezo-electric qualities found in certain minerals to circuits oscillating at radio frequencies introduced a means of frequency stability that has not since been improved upon, except to the extent of improving the crystals themselves and the circuits in which they are used. Before the advent of piezo-electric oscillators other means were employed, making use of mechanical vibrations. But these systems were confined to frequencies in the audio and low supersonic ranges and were of no use in high-frequency transmission. Such devices as the electrically-driven tuning fork were mainly used as frequency standards.

When using mechanical vibrations it becomes necessary to provide a means of coupling whereby the mechanical vibrations are transformed into electrical oscillations. In the case of the tuning fork the transformation is accomplished magnetically. This type of coupling is satisfactory at frequencies up to about ten kilocycles. At higher frequencies the physical size of the vibrator necessarily becomes so small that coupling is impractical. Other reasons also prevent such a system from being used at radio frequencies. After extensive research, Professor Cady of Wesleyan University discovered that the piezo-electric quality found in certain natural crystals could be used to supply the stabilizing and coupling mechanism at high frequencies.

Present-day crystals are a far cry from the X and Y cuts old timers will recall in the early days of crystal control. The war has also stepped up and improved methods of production while increasing our knowledge of piezo-electric phenomena. Crystals should be considerably cheaper in the post-war era, and the e.c.o. may be on its way out.

Piezo-Electric Effect

At this point it might be well to define the term "piezo-electric quality." "Piezo" is taken from the Greek, meaning "pressure." The term refers to the inherent property of some minerals by which electric charges are generated on certain

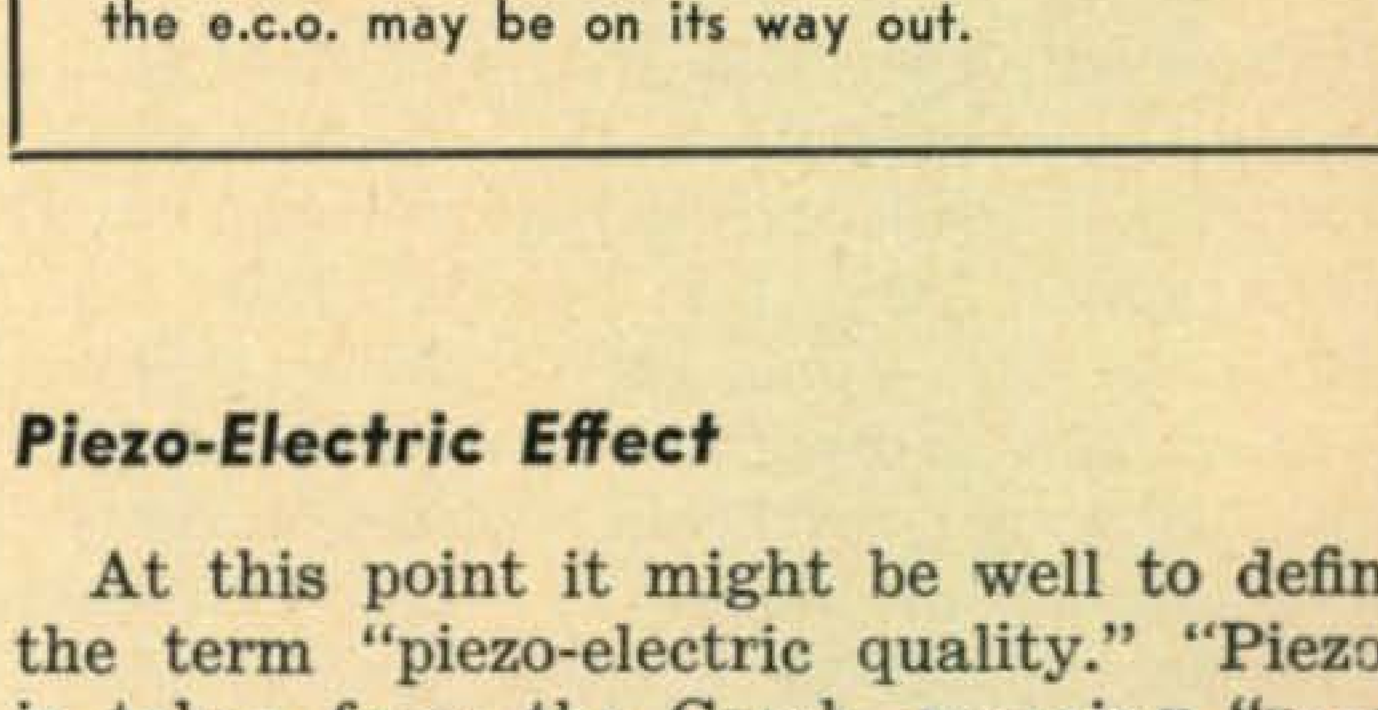


Fig. 1. Raw "mother crystal"

OSCILLATORS

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surfaces when the crystal is mechanically stressed. This property also works in reverse, in that the crystal will change its dimensions when an electrical field is applied to these same surfaces through metal electrodes.

A large number of naturally occurring minerals display the piezo-electric effect, but only two find practical application as frequency-controlling elements in radio circuits—these are quartz and tourmaline Tourmaline is not employed to any great extent at present. It was applied mainly to very-high-frequency crystals up to 30 megacycles, but developments of recent years have made possible the use of quartz at such frequencies. Quartz has taken over, as tourmaline, a semi-precious mineral, is relatively expensive.

Rochelle Salt crystals were used in the early application of piezo-electricity to

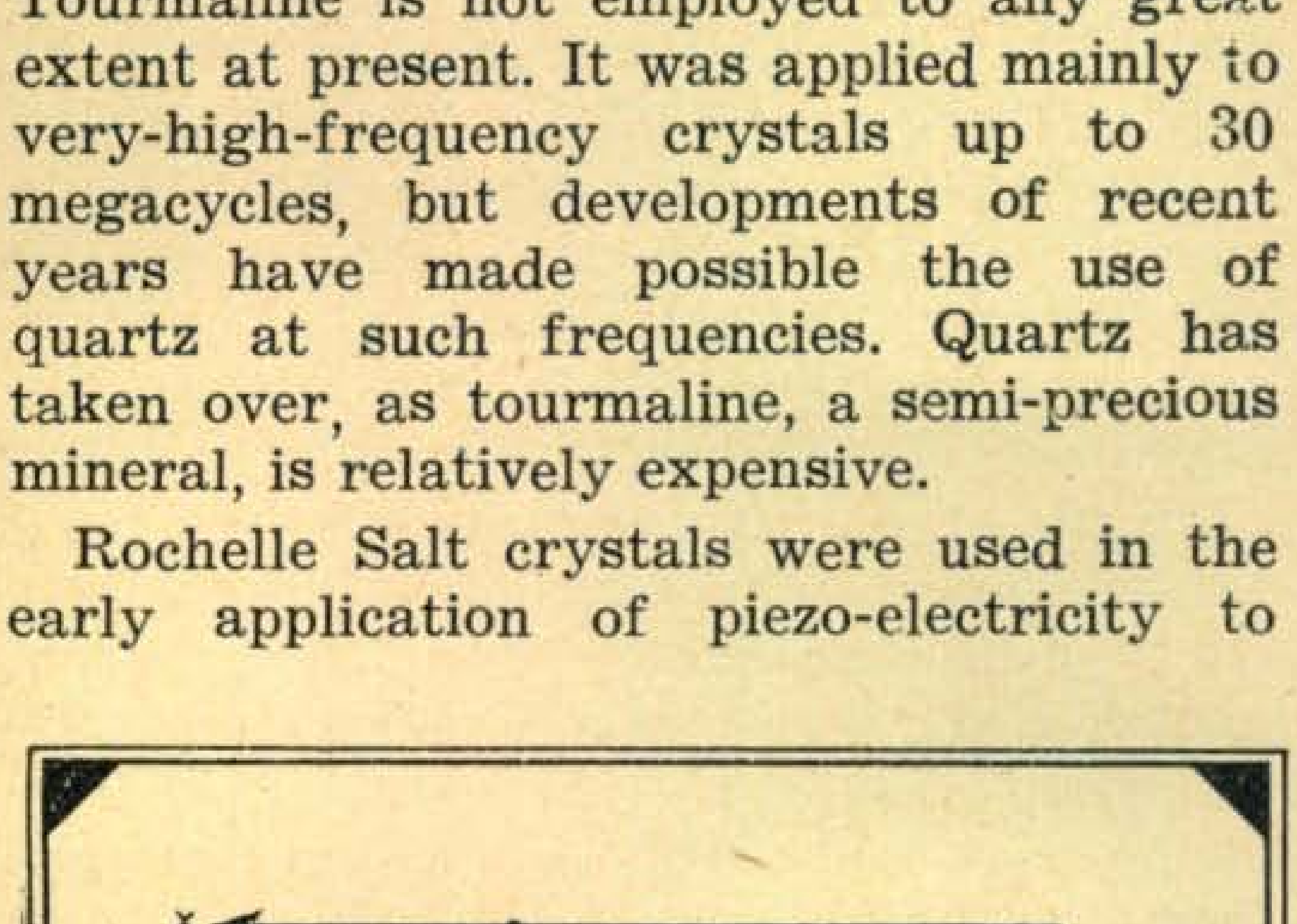


Fig. 2. Equivalent electrical circuit of a quartz crystal. C_1 represents shunt capacity due to the crystal electrodes, L the mass (inductance), C the compliance (capacity), and R the frictional resistance

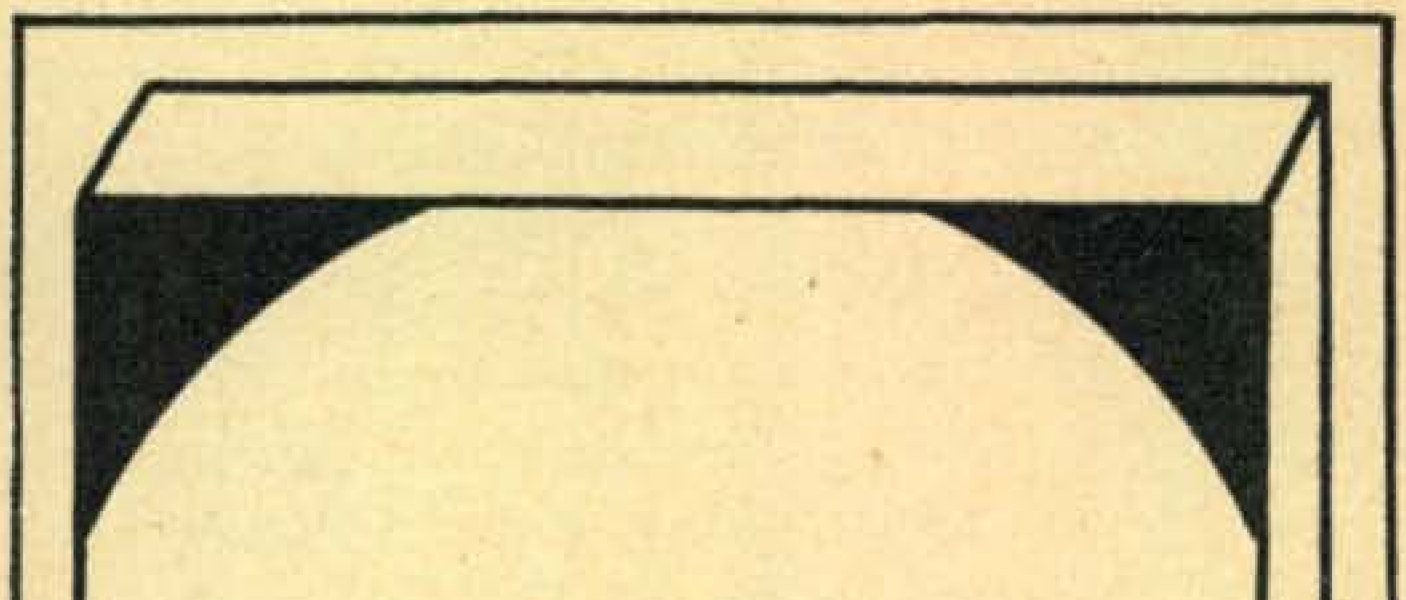


Fig. 3. Fixed air-gap pressure type electrode

oscillating circuits. These crystals, while oscillating satisfactorily (even more actively than quartz), were too porous and unstable in physical make-up to be practicle. However, because of its high piezo-electric activity, Rochelle Salt has not been forgotten and research is now in progress with the hope of devising a means whereby this substance may be applied to frequency control. Many other substances have piezo-electric qualities in varying degrees. Ordinary cane sugar has marked electrical properties as indicated by the flashes resulting when two lumps are struck together in a darkened room.

Out of the group of minerals which are active enough to be used as frequency controlling circuit elements, quartz has proved to be the best, from physical, electrical and economic standpoints. Quartz is extremely hard (7 in Moh's scale of relative hardness) and therefore cannot be scratched by the metal holder electrodes. Of equal importance is the chemical stability of quartz. It will not oxidize because it already is silicon dioxide (SIO_2).

New Optical Methods

Raw quartz is mined mainly in Brazil, although there are deposits in the United States and a few other countries. It is found in crystals of varying size which, in their ideal form, are hexagonal in shape, each end consisting of a hexagonal pyramid. In the form to which we are accustomed. *(Fig. 1.)*, only one pryamidal shaped end remains, the other having been broken off in mining. The tremendous wartime demand has made necessary the use of crystals that were not considered useable during peacetime, such as small fragments (as little as 100 grams in weight) and irregularly shaped pieces having in evidence none of the natural faces usually employed as references in determining the several axes. All measurements and angle determinations as well as inspection for various types of flaws are made to unbelievably close tolerance by means of optical methods without regard to natural faces. These amazing wartime developments have made possible the use of quartz, that, before the war, was considered scrap, and may well result in post-war ham xtals at much reduced prices.

The term "crystal," being applied to both the quartz in its natural form and to the finished oscillator may appear confusing. Actually, the quartz in its raw state should be referred to as the "crystal" or "mother crystal" and the finished product as a "quartz oscillator plate." However, as it has become customary to apply the name "crystal" to both the term will be used interchangeably in this paper, the accompanying text making clear the intent.

In order to clarify the manner in which a crystal oscillates, it is essential to possess a basic understanding of the oscillating circuit, which theoretical knowledge is here taken for granted. Resorting to mechanical analogy, the crystal may be compared with the pendulum of a clock. When oscillating, a crystal is continually changing its dimensions, becoming thinner and longer or twisting torsionally, depending upon the

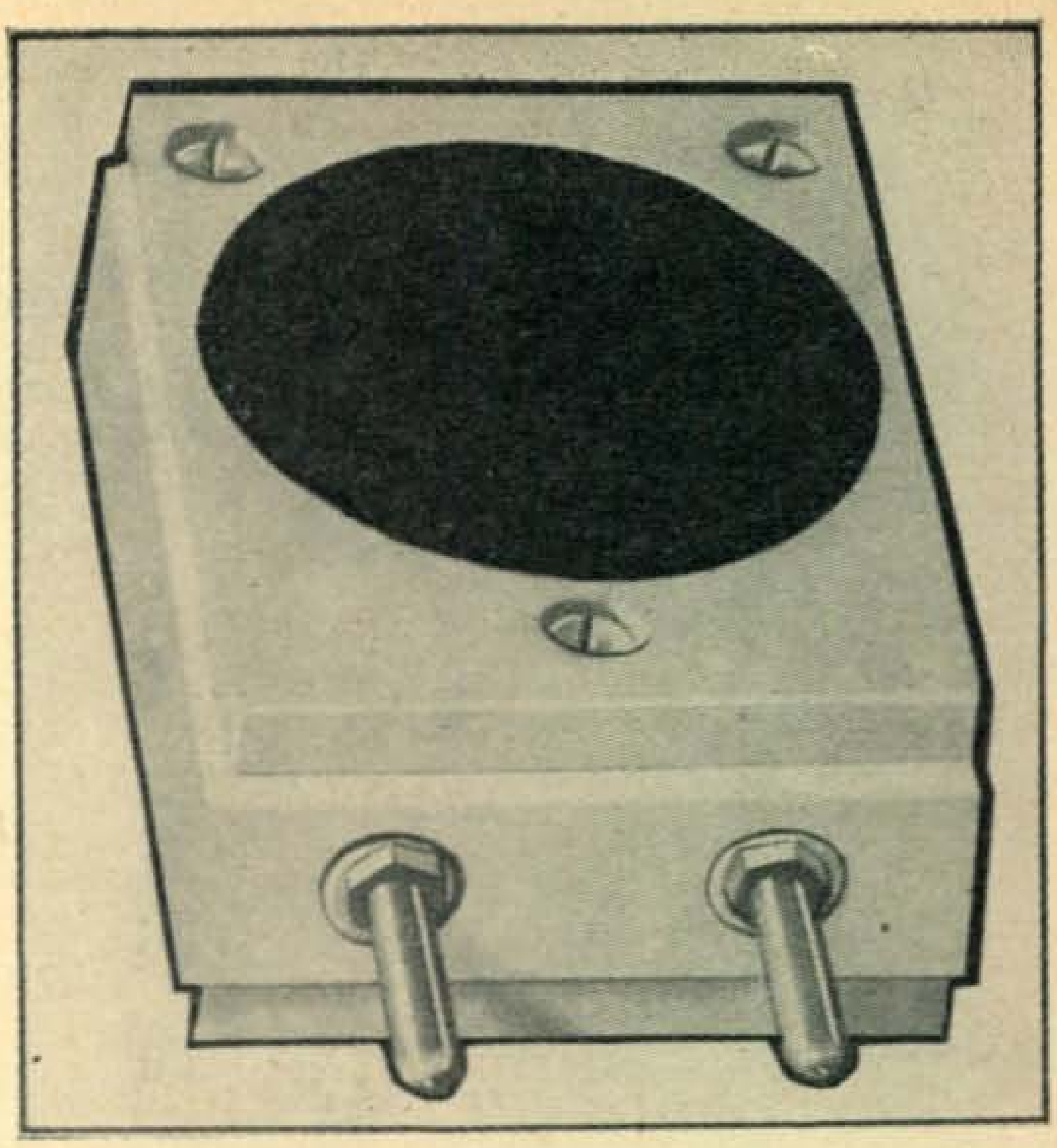


Fig. 4. Fixed or variable air-gap type crystal holder for precision applications

type of cut and the mode of oscillation employed. The application of an electric field to the crystal electrodes will distort the crystal and when this field is removed or the polarity reversed, the crystal will tend to return to its original shape and, due to the momentum gained in doing so will go through its static dimensions and change shape in the opposite direction to that of its first distortion. This motion is due to the inherent elasticity of quartz and will continue for a few cycles, the amplitude of each cycle becoming familiar until the crystal is again at rest. The crystal action can be compared with that of a clock pendulum which has been disconnected from the works. If moved from its "at rest" position and released, it will swing back and forth, the distance of each swing becoming smaller until the pendulum is again at rest. But what if the clock mechanism is connected? At exactly the right moment during each swing the pendulum is given a little push and it continues to swing or "oscillate," the distance or "amplitude" of each swing remaining the same. The time required for each oscillation is determined by the characteristics of the pendulum, and this action can again be likened to that of the crystal. If the polarity of the voltage applied to the electrodes is changed periodically, the crystal will oscillate or vibrate, **provided the frequency of the voltage reversal corresponds to the natural frequency of the quartz** plate, which is determined by its dimensions. Thus the circuit will oscillate at a frequency set by the crystal and the crystal is said to control the frequency. Oscillation of the circuit is due to the crystal in turn supplying alternating excitation voltage at radio frequency to the grid circuit of the oscillator stage.

The equivalent circuit of a quartz crystal is shown in *Fig. 2*. By equivalent is meant the circuit components that can be substituted in place of the crystal and still permit the circuit to oscillate. However, we would then have a self-excited oscillator with none of the advantages of the crystal oscillator, particularly the extremely high frequency stability which is its feature.

Crystal Cuts

Almost any substance will change its dimensions when the temperature of the medium in which it exists is varied. This change will be of varying degree, depending upon the material, and it may be positive or negative; that is, it may expand or contract with a rise in temperature. This basic law of course applies to quartz and as the frequency of a crystal is dependent upon its dimensions it is quite obvious that if the temperature is varied, the frequency will change. Most materials have a fixed coefficient of expansion and this fact might lead to the belief that the frequency of a quartz crystal will vary directly as the coefficient of expansion of quartz. This does not always hold as will be shown. We have said that the frequency of a crystal is dependent upon its dimensions. This is true but only to a certain extent. The frequency is dependent upon the dimensions but not three dimensions as a whole. The length, width and thickness affect the frequency individually to a degree depending upon the angles at which the plate was cut from the mother crystal. Two dimensions may have a positive temperature effect while the other has a negative effect and vice versa. The overall frequency drift with a change in temperature is the result of the algebraic addition of these several influences. This unusual phenomenon is due to the complex atomic structure of quartz, the study is a science in itself, having to do with Young's modulus, the basis of elasticity, etc.

From the foregoing it is clear that if a crystal could be cut at a certain angle from

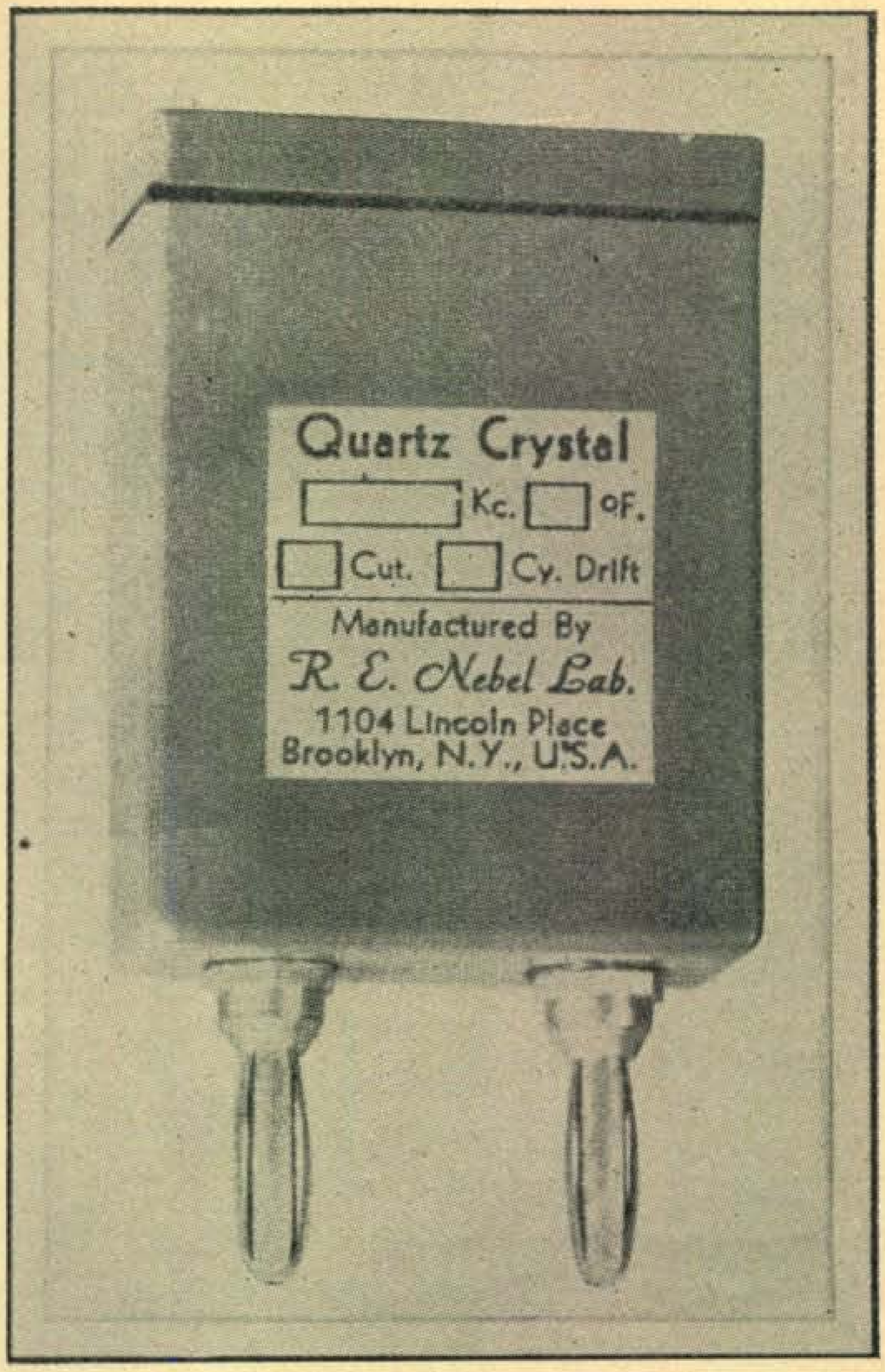


Fig. 5 Pressure type crystal holder for general use

the mother crystal whereby the positive effects could be made to equal exactly the negative effects, we would have a crystal the frequency of which would not vary when subject to a change in temperature. This is exactly what has been accomplished during recent years and as a result we have what are called "low-drift" crystals such as the AT, BT, AC, V, E and GT cuts. This nomenclature refers to the angles at which the plate is cut from the mother crystal with respect to the several natural axes. The reason for their being more than one low-drift cut is that some are more suitable for one purpose than another. For instance, the AT is better suited to lower frequencies as it is thinner for a given frequency than the BT cut. The latter, being thicker and therefore less fragile, is used mainly on frequencies above 4000 kilocycles. The CT cut is employed as a harmonic type plate. That is, it will oscillate readily at its third harmonic when properly ground. This make is possible to obtain a higher frequency output from an oscillator stage. For example, if a CT cut

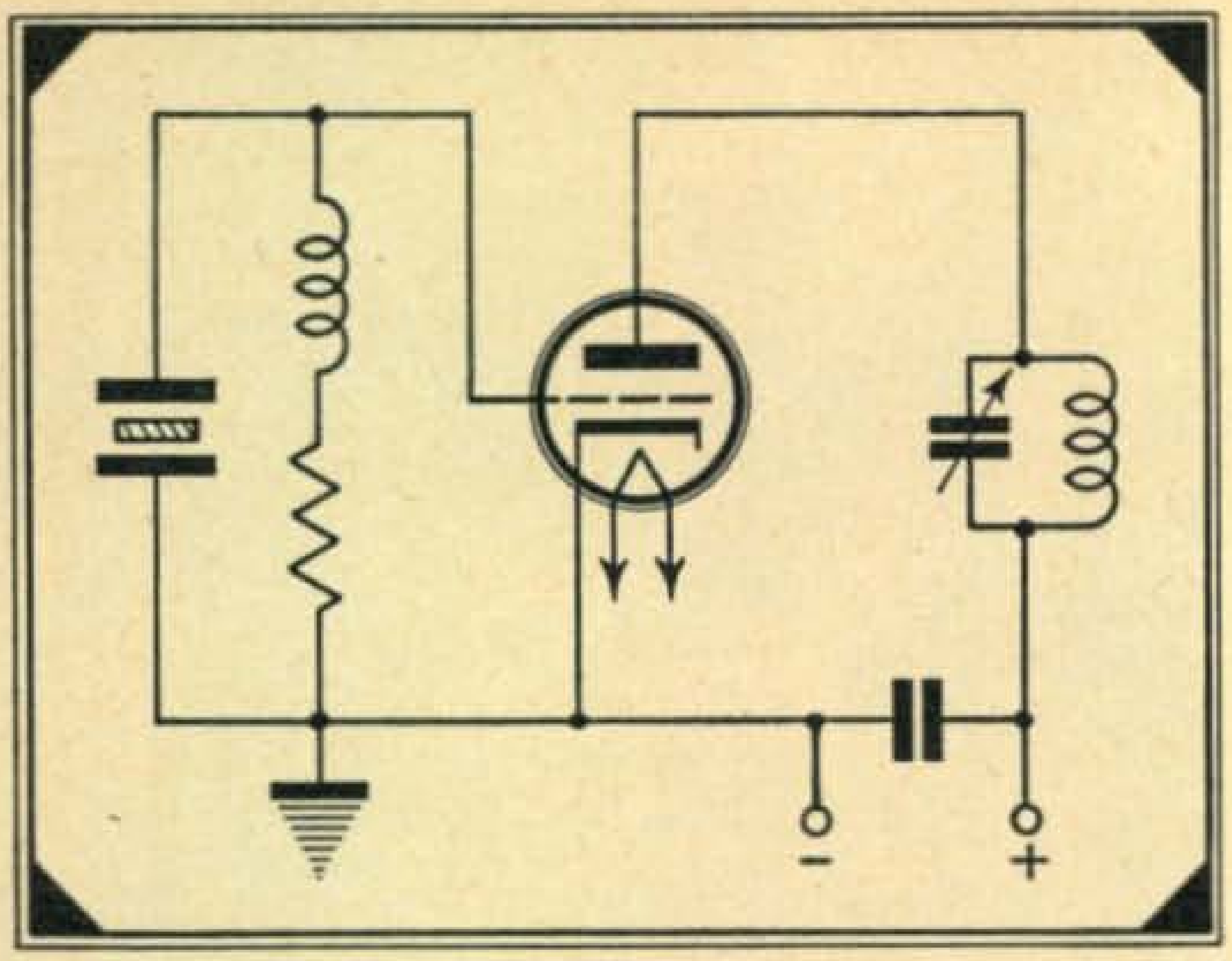


Fig. 7. Triode crystal oscillator circuit

is properly ground to 7000 kilocycles (fundamental), output is obtained at 21,-000 kilocycles, by exciting its third harmonic.

Temperature Effects

Reference has been made to a crystal the frequency of which will not vary when it is subjected to a change in temperature. Due to the nature of quartz this is possible over only a limited variation of temperature. To produce a "zero drift" crystal is theoretically possible but, in practice, a loss of activity would be suffered and the temperature still could not be varied over a very wide limit if the drift were to remain zero. We therefore must specify the drift coefficient of a crystal in terms of the average drift over the temperature range to which it is to be subjected. Thus we never see a drift coefficient specified as "zero." It will usually appear as a numerical coefficient with the temperature range indicated such as "4 cy. /°C./Mc., -25°C. to + 50°C." This means that the crystal will have an average drift of four cycles per megacycle per degree centigrade change in temperature within the temperature limits indicated. For example, we have a crystal that is marked "2 cy./°C. /Mc., 0 to 50°C." The frequency is measused when the crystal is at room temperature and found to be exactly 7000 kilocycles. If the temperature is then raised 10°C., the frequency will drift approximately 2 x 7 x 10 = 140 cycles. In almost all low-drift cuts the drift is positive so the frequency will now be 7000.14 kilocycles. When the temperature range is not specified but the drift coefficient is, such as in amateur type crystals, the temperature range is taken to be that normally encountered in operation in the average amateur station. This range can only be an approximation as there are other influences beside the ambient (room) temperature which cause temperature variation of the crystal. The crystal iteslf, which is vibrating mechanically, will generate heat, depending upon the type of oscillator circuit, the efficiency with which it operates, the plate voltage used on the oscillator tube, the activity of the crystal (which is a measure of the amplitude of vibration and thus the amount of friction causing heat), etc. The crystal may be located where it is subject to heat from tubes, resistors and other circuit components. The design of the crystal holder and the electrodes also have a bearing on the temperature variation of the crystal.

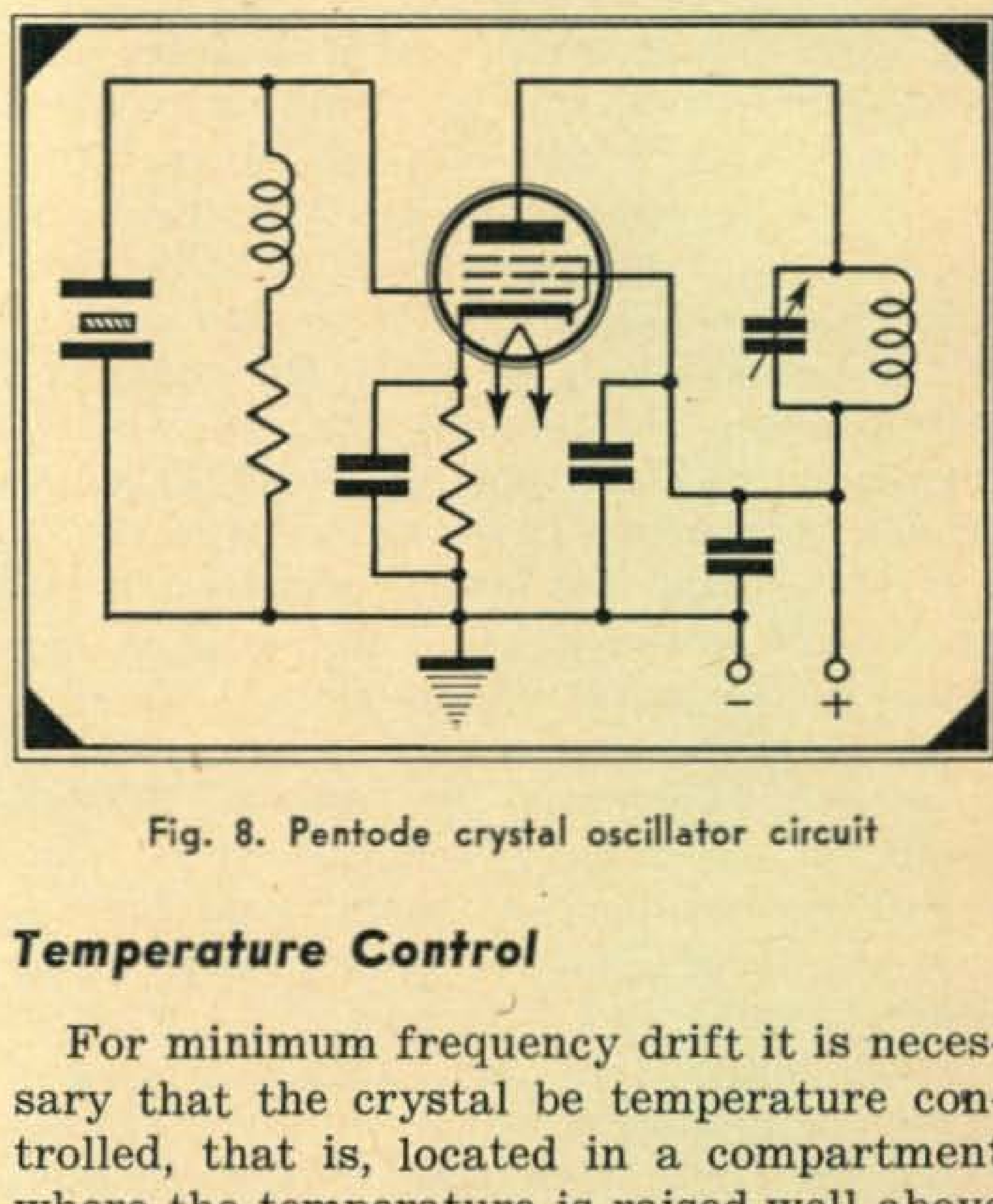


Fig. 8. Pentode crystal oscillator circuit

Temperature Control

For minimum frequency drift it is necessary that the crystal be temperature controlled, that is, located in a compartment where the temperature is raised well above that to which the crystal would rise due to normal influences. The temperature of this compartment must be held to its designated value within a fraction of a degree—this being accomplished thermostatically. The frequency of the crystal must of course be measured at the higher temperature as this will be its operating frequency. The temperature at which the crystal was calibrated will be found marked on most crystal holders, the frequency at that temperature also being indicated. Most amateur crystals are calibrated at room temperaature, unless otherwise specified.

A most important adjunct to the performance of a quartz crystal is its holder or, more precisely, the metal electrodes between which it is mounted. The electrodes accomplish two purposes in most types of holders. Primarily, they serve as a means of applying the electric field to the crystal and, in most cases, they clamp the crystal firmly so that it will not change its position with relation to the electrodes, which change might shift the frequency slightly. Early crystals such as the X and Y cuts (now practically obsolete due to high drift coefficient) made use of perfectly flat plates in intimate contact with the crystal and held in place by light spring pressure. The pressure could not be very great as the oscillations would then be damped with loss of activity. Because of the necessarily light pressure the crystal unit was not very stable mechanically, minor shocks or jarring resulting in a slight change in frequency. Frequency shift is caused by a change in the damping of the crystal, brought about by the variation in pressure on the electrodes, and also by variation in capacity across the crystal as the electrodes change position and distance in relation to each other. This slight frequency change is used to advantage in the variable air-gap holder. One of the electrodes is attached to a shaft having a micrometer thread, the end of which is slotted and accessible from outside the holder where it may be screwed in or out by use of a screwdriver. The air space (or air-gap) between the crystal and the movable electrode is thus

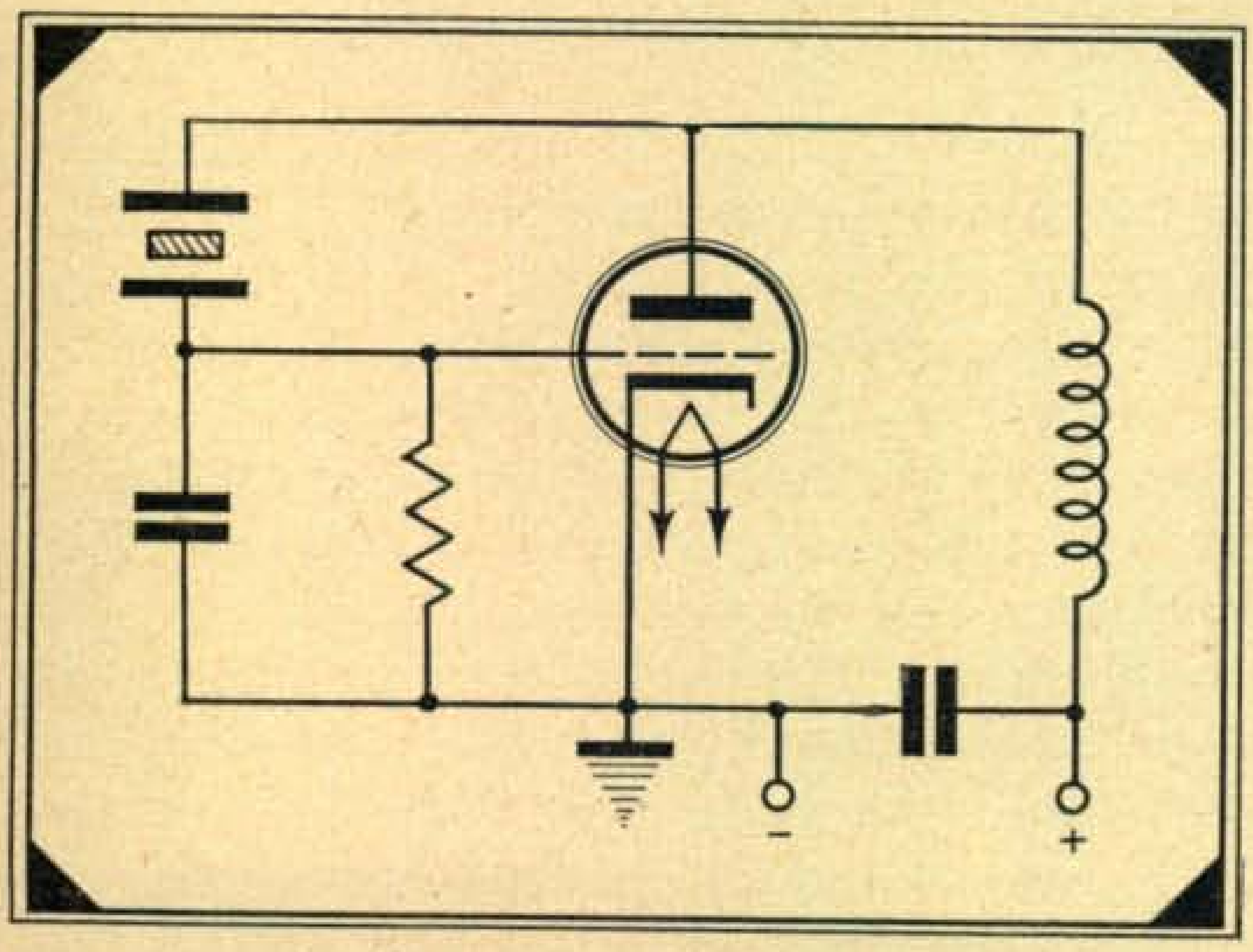


Fig. 9. Pierce crystal oscillator circuit

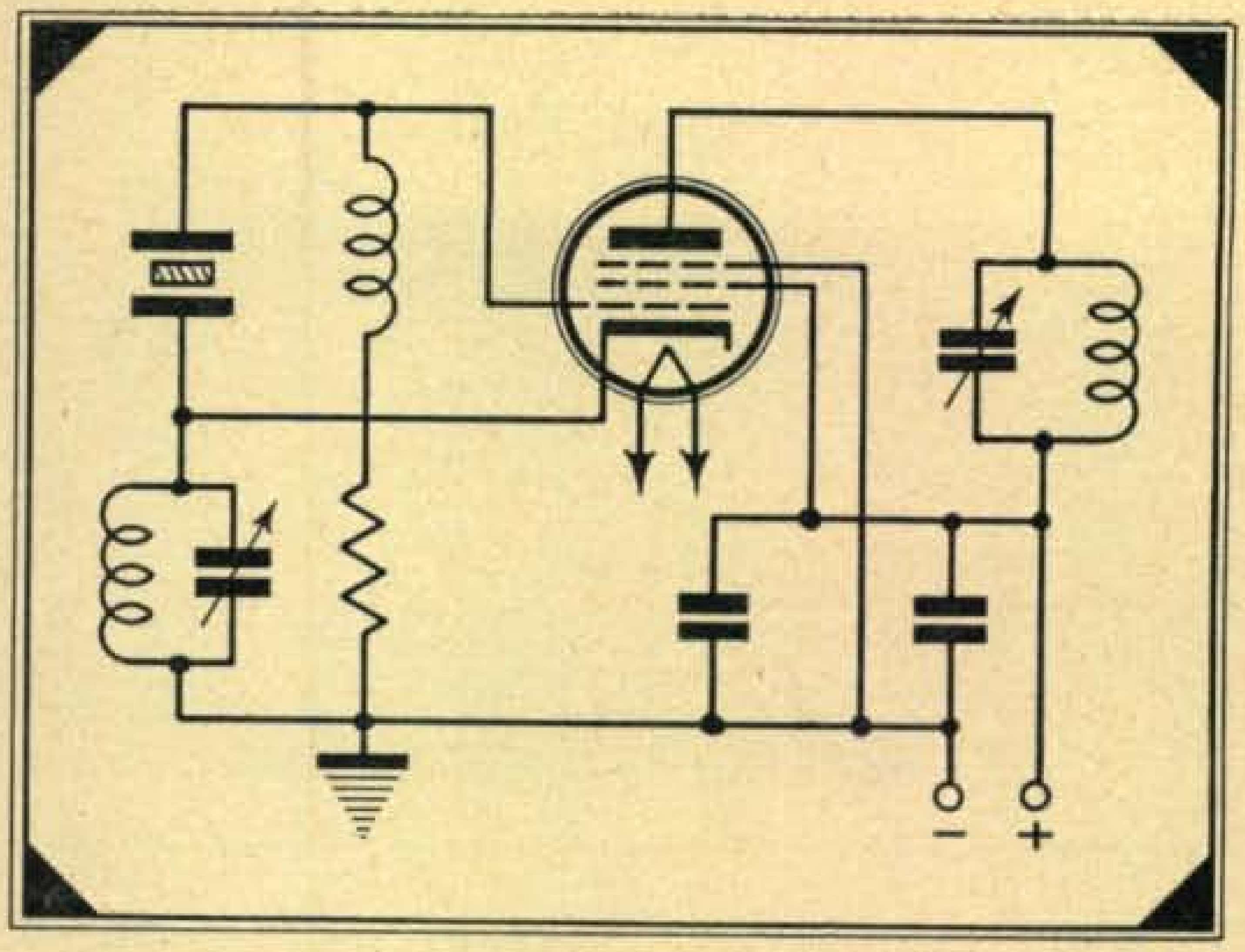


Fig. 10. Tri-tet crystal oscillator circuit

adjustable, the frequency of oscillation varying in accordance with the size of the air-gap. As the air-gap is increased the frequency of the crystal also increases but the activity falls off so there is a very definite limit to the size of the air-gap. The crystal is not in contact with the movable electrode—and therefore must be anchored so it cannot move around in the holder. This is accomplished by means of a retainer plate containing a hole just the size of the crystal in which the crystal rests without lateral movement. This type of holder is advantageous where extremely precise adjustments of frequency must be made such as in broadcast work. It is not suitable, however, for very-high-frequency crystals.

In some instances the electrodes consist of thin coatings of metal on the crystal, usually silver, which is deposited chemically or by a sputtering process. Connecting wires are soldered to each face. In the small communications frequency crystal of this type the wires are stiff and form a means of supporting the crystal in free space. The assembly is of course enclosed in a holder. Before the present war developments, the use of the plated crystal was usually confined to low frequencies as a standard. The crystal is clamped between knife edges of insulating material along a nodal axis, this axis being a point (usually along a line across the exact center) at which there is no motion of oscillation. This permits the crystal to be clamped very rigidly with no loss of activity. Contact is made to the plated surfaces by means of small metal fingers.

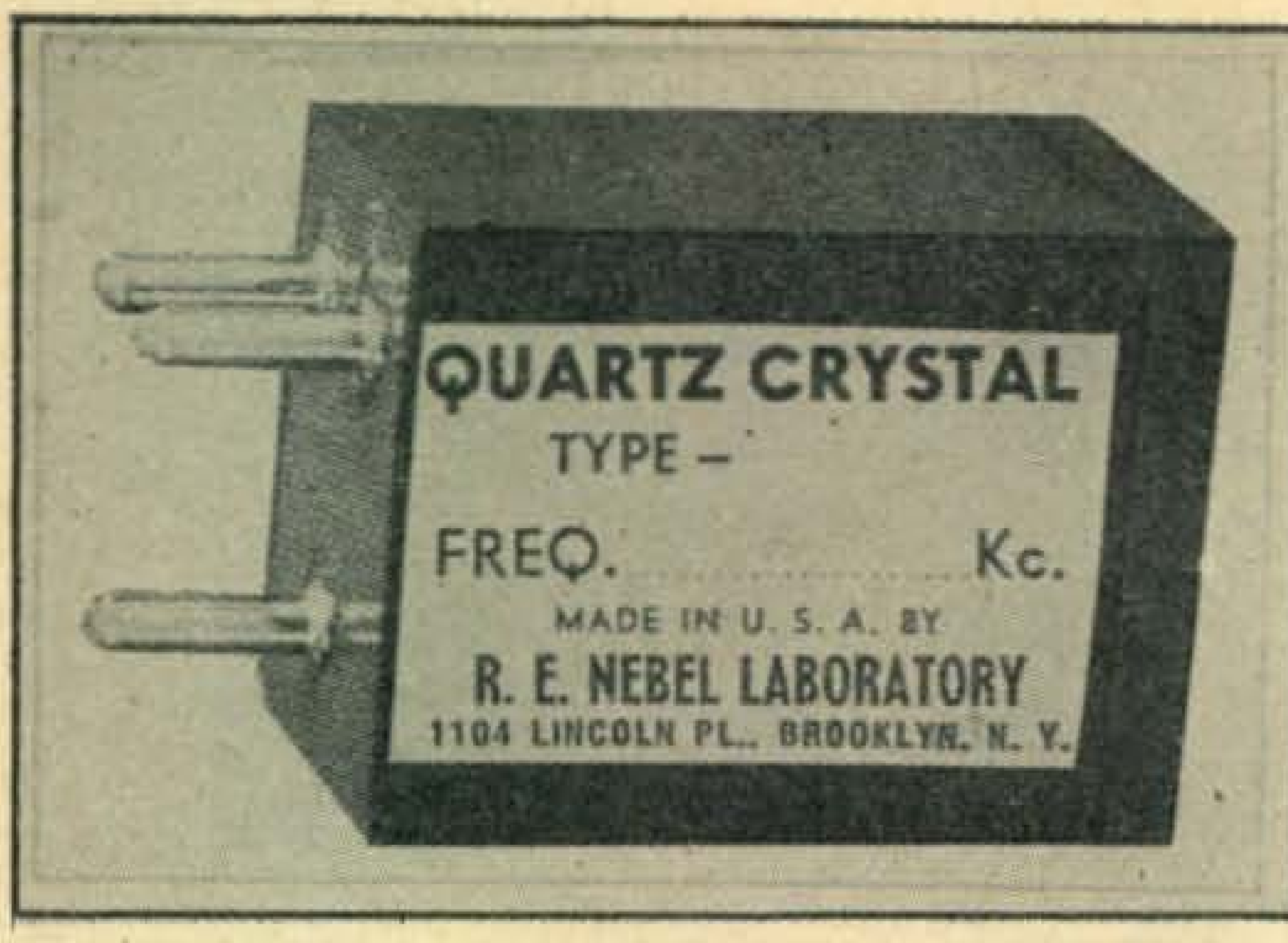


Fig. 6. Dual type (two crystals) crystal holder for marine and aircraft use

Communications Types

The most widely used type of electrode for communications frequency crystals today is the pressure air-gap type. This is illustrated in *Fig. 3*. The black portion represents the corners which come in contact with the crystal. These corners are from a few ten-thousandths to one or two thousandths of an inch higher than the center (white portion), the center having been turned on a lathe, ground out, or etched with acid. When placed between two of these electrodes the crystal will be supported by its four corners, the center being free. A good deal of pressure may be used, making the assembly very solid mechanically. The AT and BT cut plates used with this type of mounting have nodal points at the corners and therefore the amplitude of oscillation will not be damped by pressure.

Another type is the hollow-ground electrode. This employs the same principal as the pressure air-gap design but instead of the center being turned out to an even depth it is ground concave, with the crystal clamped by the four corners.

Fixed air-gap mounting is used in some cases, particularly where maximum activity is required as in low-frequency filters used in receivers. In this case flat electrodes are employed and insulating spacers, one or two thousandths of an inch thicker than the crystal are placed on each side of the crystal. These spacers permit the crystal to float freely with no damping of oscillations. The material of which the spacers are made must be chosen so as to have a coefficient of expansion as close to that of quartz as possible in order to minimize frequency drift due to variation of the air-gap. The material generally used is Pyrex glass.

There are many types, shapes and sizes of crystal holders in general use. The war has made necessary the design and development of many new types suited specifically to the peculiar needs of military communication equipment. It will be found, however, that no matter what the external appearance, the crystal will be mounted by means of one of the aforementioned methods. In some cases, where a crystal is used as a standard of frequency, or where-ever the utmost is desired in making it impervious to external influences such as humidity, atmospheric pressure, etc., a metal tube envelope is used, first evacuating it and then admitting an inert gas such as argon. A few representative types of crystal units are shown in *Figs. 4, 5* and *6*.

Crystal Circuits

So far we have considered quartz crystals in light of their relative merits as frequency controlling elements. In order to perform their basic function they must of course be connected in the proper type of circuit so as to utilize their ability as oscillators. It follows that the associated circuit components and their operating conditions will directly influence the performance of the crystal. This influence can be good or bad. An understanding of the basic requirements for stable operation of the crystal and the various types of circuits suitable for use as crystal controlled oscillators will enable the user to obtain the utmost in frequency stability in keeping with the present state of the art.

It should be borne in mind that in practically every case, particularly so with transmitters, it is frequency stability that is sought, power output being a secondary consideration. If more power is required than can be delivered by a crystal-controlled oscillator, power amplifiers may be used to reach the desired level. The crystal oscillator itself is capable of producing an appreciable amount of power but if a certain limit (depending on the type of circuit and its operating conditions) is exceeded frequency stability will suffer, due to the crystal warming up.

The most commonly used circuit in past years has been the triode oscillator shown in *Fig. 7*. The triode oscillator performs very well with crystals at all frequencies. Plate-grid feedback, necessary for oscillation, is provided by the internal grid-plate capacity of the tube. For low frequency crystals it is desirable to use gridleak bias. On frequencies above approximately 1700 kilocycles cathode bias is preferable. For most stable oscillation a low L/C tank ratio should be used. This will reduce the crystal r.f. current (with heating effect) and thus minimize frequency drift. The plate voltage directly influences the stability of the circuit and should be kept as low as possible, the value depending upon other conditions of operation—tank L/C ratio, bias and amplification factor of the tube. The voltage may be anywhere between 100 and 350 volts. In amateur applications power outputs up to 5 watts are customary.

The pentode oscillator is shown in *Fig. 8*. This type of circuit has been employed most extensively in very recent years by the amateur ranks. The following description also applies to the tetrode oscillator, the fundamental difference being in tube structure. For amateur communication frequencies a combination of gridleak and cathode bias proves most advantageous. The value of screen voltage is most important due to the fact that it has more influence on the crystal current than the plate potential. Higher plate potentials may be used with the pentode or tetrode oscillator than with the triode due to the action of the screen grid which limits crystal current by means of reduced grid-plate capacity and thus reduced feedback. Higher plate voltages mean more output without exceeding the safe limit of r-f crystal current. With pentodes and tetrodes designed for use at radio frequencies outputs as high as 15 watts may be obtained.

The Pierce or untuned oscillator may employ either triode, pentode or tetrode tubes. in the circuit of Figure 9, a triode is illustrated. This type of circuit is well suited to equipment where compactness is a necessity due to the fact that the tuning capacitor and associated coil are eliminated. A small r.f. choke coil of suitable value is used in the plate circuit. In order to oscillate, the plate circuit should be characterized by a negative or capacitative reactance. This means that the plate choke must have a natural resonant frequency lower than that of the crystal. Feedback is controlled by the grid-cathode capacitor. It is important that the value of this condensor is not too high as excessive feedback can damage the crystal. The main advantage of the Pierce oscillator is its simplicity and convenience of operaton. It is limited to low power outputs in comparison with the previously described circuits.

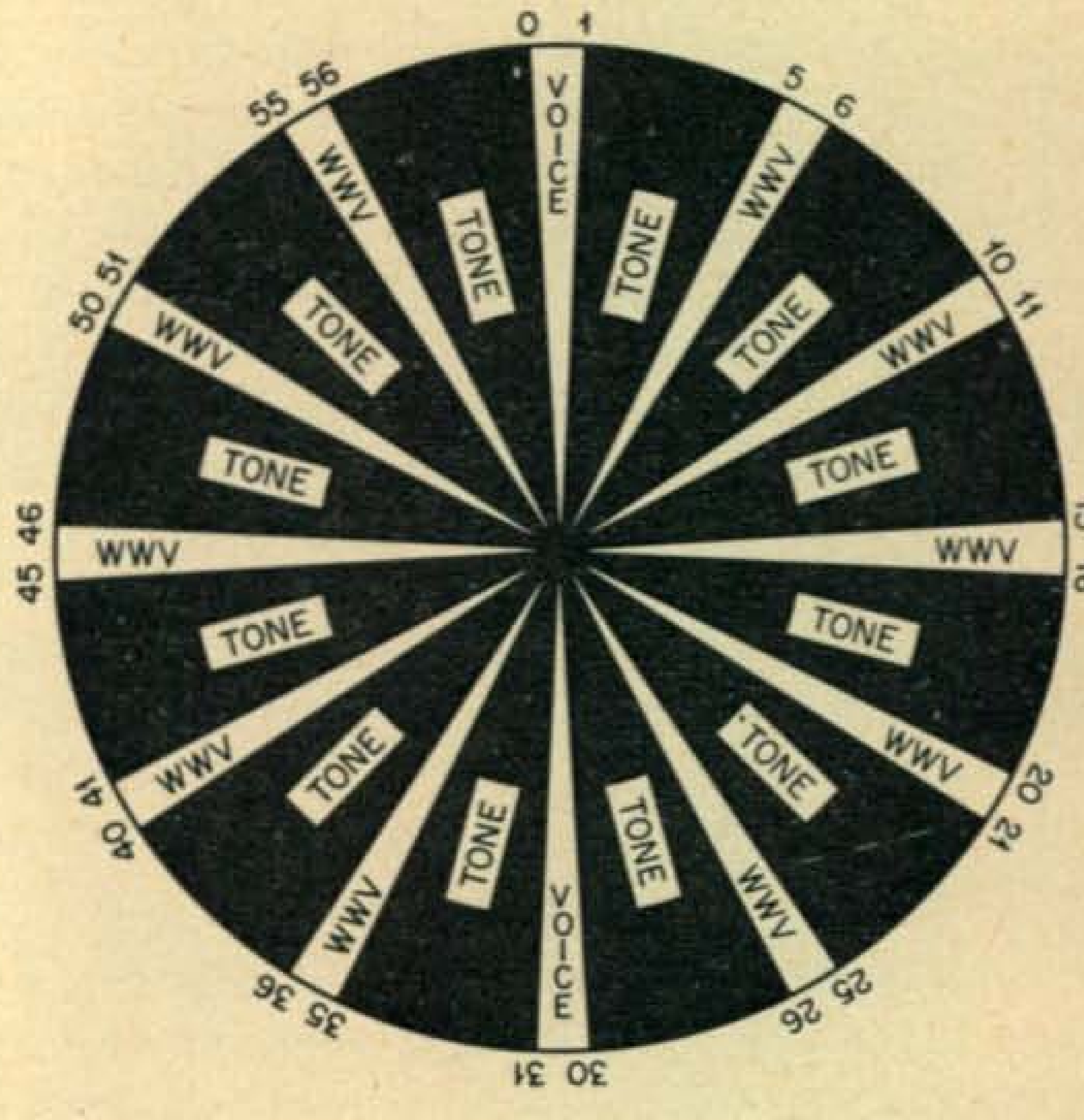
The Tri-tet

There are a number of other arrangements in general use whereby frequency multiplying is accomplished within the oscillator stage. A circuit of this type, very popular among amateurs, is the Tri-tet illustrated in *Fig. 10*, in which the oscillator is a triode consisting of the cathode, grid with the screen-grid serving as the plate. As the tank is in the cathode circuit, the screen grid may be grounded with respect to r.f. The tank in the output or plate circuit is tuned to a harmonic of the crystal frequency and usable output may be of a fairly high order, usually limited in amateur application to the fourth harmonic. Regeneration is present, aiding in harmonic production, in that the cathode tank carries both the fundamental and harmonic frequency currents. Circuits of this type require very careful design and adjustment in order to prevent excessve crystal current. Slight misadjustments can cause such high r.f. currents through the crystal as to fracture it. Selection of tubes specifically designed for r.f is necessary in order to insure adequate shielding.

As will probably be the case when surplus materials become available to the public after present hostilities cease, radio amateurs may be able to obtain crystal units manufactured for the Army and Navy. Too much faith must not be placed in the accuracy of the frequency marked on the holder as this frequency applies only in the equipment for which the crystal was made. In all cases it will be best to have the frequency of the crystal rechecked in an accepted standard oscillator circuit, especially if the frequency happens to be near the edge of an amateur band.

WWV

STANDARD FREQUENCY BROADCAST SERVICE



L. W. LAWRENCE

THE standard-frequency broadcast service of the National Bureau of Standards comprises the broadcasting of standard frequencies and standard time intervals from the Bureau's radio station WWV near Washington, D. C. It is continuous day and night, from 10-kilwott radio transmitters, except on 2500 kilocycles where 1 kilowatt is used. The services include: (1) standard radio frequencies, (2) standard time intervals accurately synchronized with basic time signals, (3) standard audio frequencies, (4) standard musical pitch, 440 cycles per second, corresponding to A above middle C.

This broadcast services makes available standard frequencies internationally which are of value in scientific and other measurements requiring an accurate frequency. Any desired frequency may be measured in terms of any one of the standards, either audio or radio, by means of harmonies and beats, with one or more auxiliary oscillators.

The radio frequencies are:

- 2.5 megacycles (= 2500 kilocycles = 2,-500,000 cycles per second), broadcast from 7.00 P.M. to 9:00 A.M., E. W. T. (2300 to 1300 G. M. T.)
- 5 megacycles (= 5000 kilocycles = 5.-000,000 cycles per second), broadcast continuously day and night.
- 10 megacycles (= 10,000 kilocycles = 10,000,000 cycles per second), broadcast continuously day and night.
- 15 megacycles (= 15,000 kilocycles = 15,000,000 cycles per second), broadcast from 7:00 A.M. to 7:00 P.M., E. W. T. (1100 to 2300 G. M. T.)

At least three radio carrier frequencies are on the air at all times, to insure reliable coverage of the United States and other parts of the world. Two standard audio frequencies, 440 cycles and 4000 cycles per second modulate the radio carrier frequencies. Both are broadcast continuously on 10 and 15 megacycles, and on

[*Continued on page 39*]

PORTABLE MAST

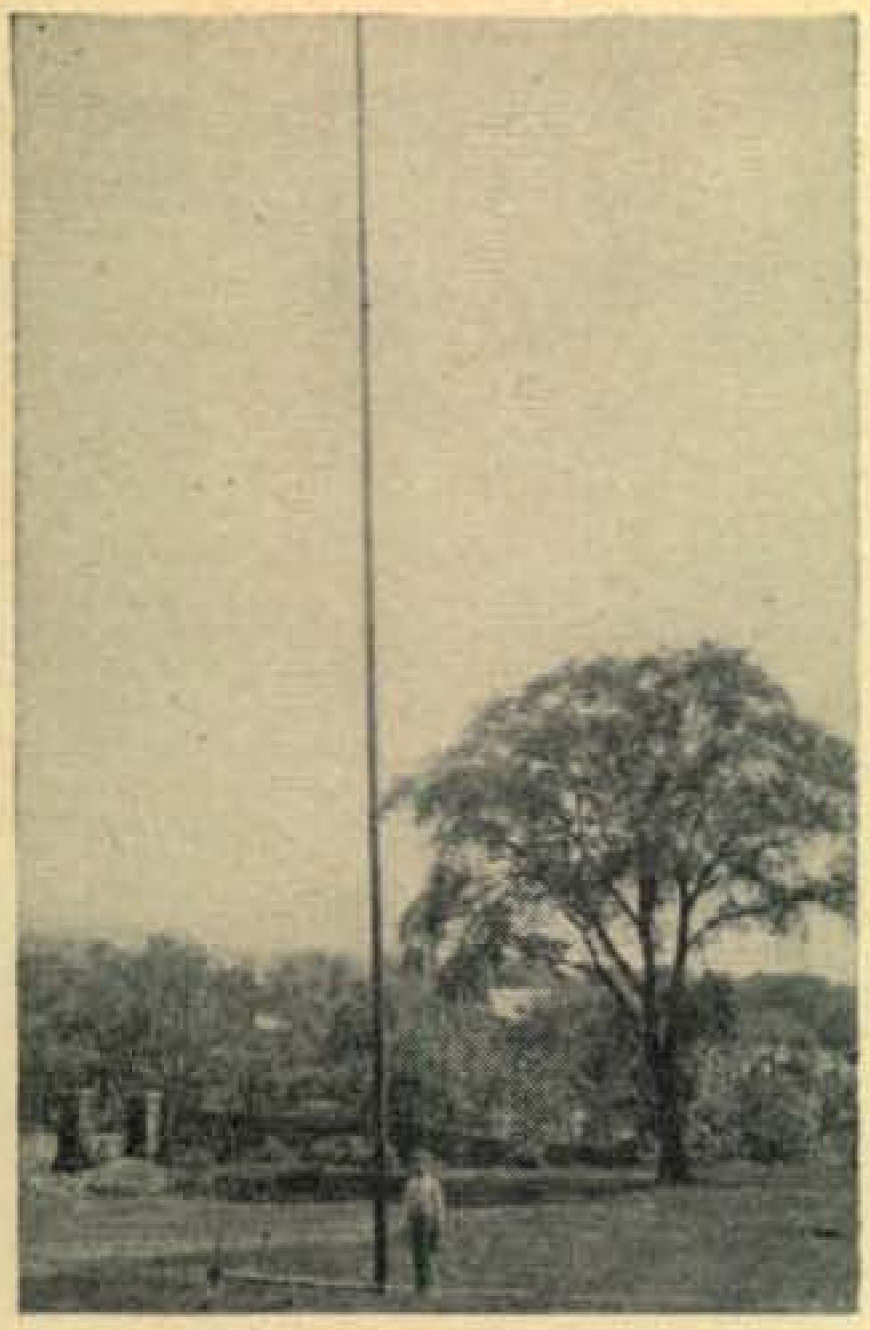


Fig. 1

PAUL M. KENDALL

Plymold Corp.

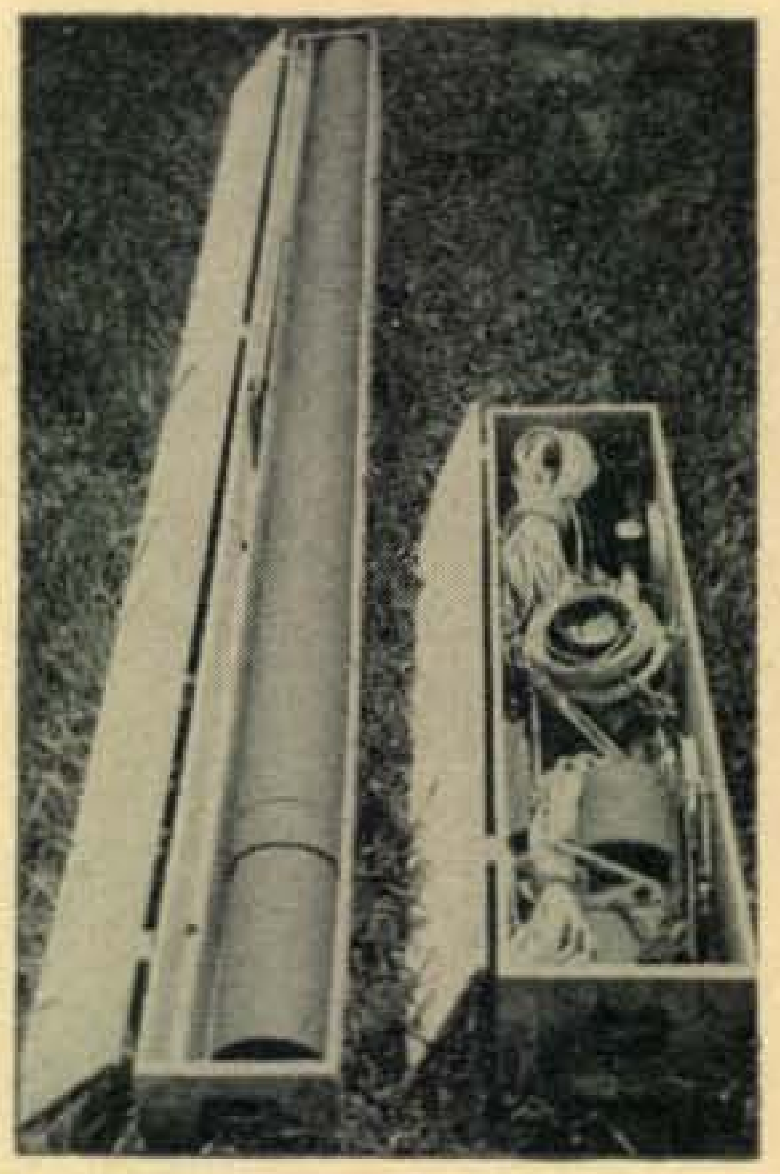


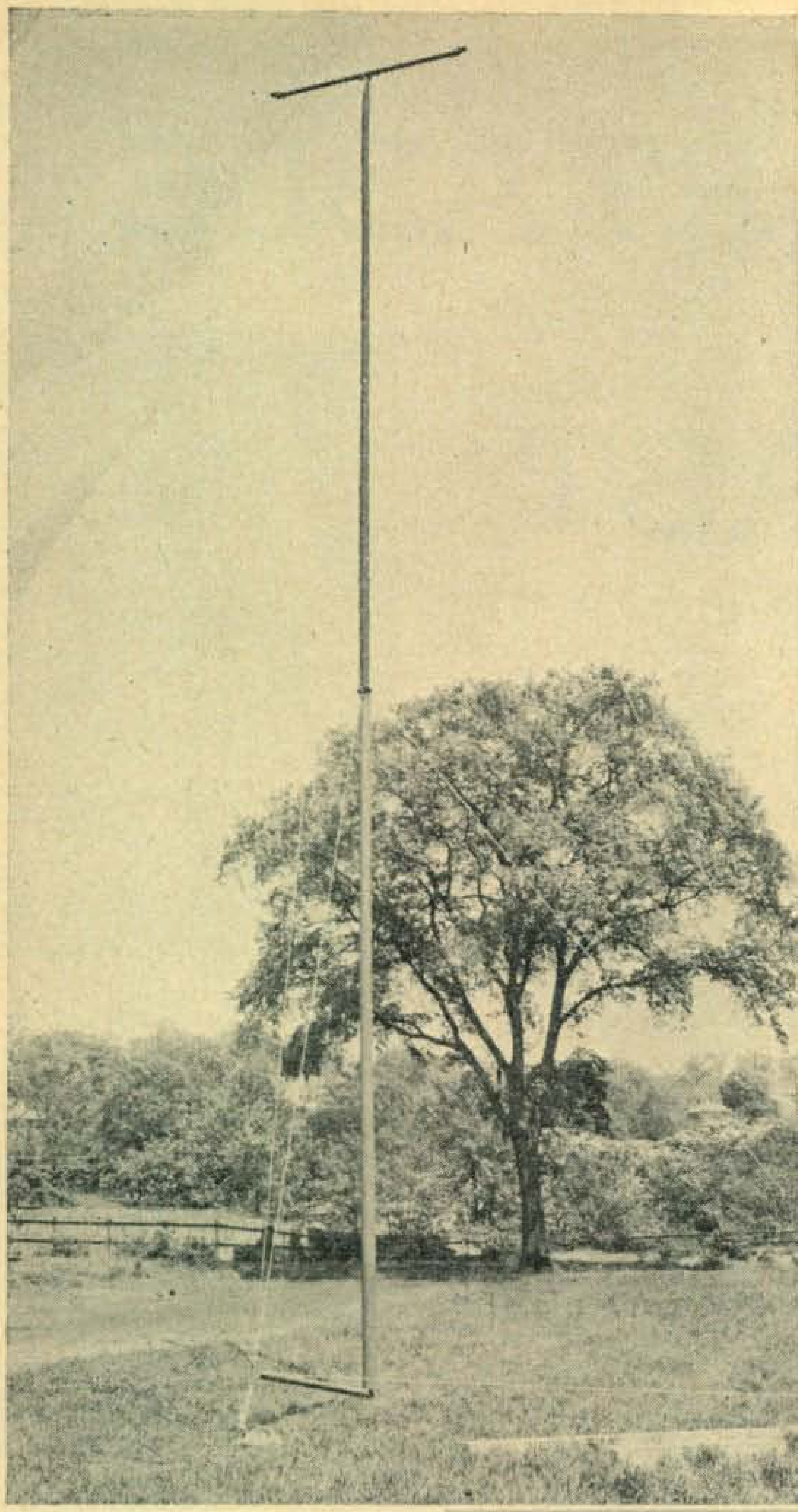
Fig. 3

The development of a portable, telescopic, extra-light, tubular plywood antenna mast has recently been announced by the Plymold Corporation of Lawrence, Mass. The mast is being manufactured in a variety of models to meet the requirements of antennas and antenna arrays in all frequency bands. Heights up to 90′ are available on order, with standard heights of 50′, 55′, and 75′ carried in stock for immediate shipment. All masts are designed in sections not exceeding 12′ in length. In shipment, these sections nest into one another forming one or two package of small dimensions. Fittings, stays, and erection equipment are packed in a reusable case. If necessary, the mast complete with accessories may be hand carried to location, making it ideal for erection at sites to which roads are not available. Should it become necessary to move the mast from one site to another, every member is completely reusable, and change of location is accomplished with a maximum of ease.

The advantages of directive antenna arrays for both radio transmission and reception have long been evident, but with the development of equipment designed to operate on ultra-high frequencies, their importance has increased many times. Also, at these UHF frequencies, the height of the radiating elements becomes critical in ground to ground communications, inasmuch as there is no reflection of the waves by the ionesphere, and the only effective waves are those which have a clear path through the atmosphere. Both FM and television falling into this category, the wide application of a mast of this type becomes evident.

Masts are furnished with accessories so that they will be suitable for use either as an end support for horizontal antennas, or as the complete support for UHF antennas. For horizontal antennas, masts have been designed and tested for a maximum antenna pull of 0,000 pounds, which is suitable for long, three element rhombic arrays. For UHF antennas, masts have been designed and tested to support a load of 300 pounds at the head, which far exceeds the load imposed by a UHF array. By the use of a special fitting at the head of the mast, the array can be made rotatable in azimuth, and if required, in elevation. Anyone who has been faced with the problems of UHF reception from transmitters located in different directions can readily appreciate the marked advantages of a readily revolvable antenna array.

The method of erection of these antenna masts is unique, inasmuch as one man can erect masts up to 55′ in height, and only two men are necessary for masts up to 90′. No special experience is required, the instructions supplied with each mast being sufficiently self-explanatory for the layman to erect the mast in a few hours. Once erected, the mast may



be lowered and raised in a few minutes, making frequent antenna changes possible when necessary. Masts are designed and tested to withstand wind velocities of 125 miles per hour. In the recent hurricane when wind velocities of 95 MPH were recorded in areas where these masts are erected, not one case of mast failure occurred.

Fig. 1 illustrates a 75′ mast, and *Fig. 2* a 55′ mast with cross-arm. *Fig. 3* shows how mast and accessories are packed for shipment in packages where weight and volume are exceedingly small. For example, the 55′ mast illustrated in *Fig. 3,* has a shipping weight of approximately 200 pounds, and occupies a volume of less than 10 cubic feet. *Fig. 4* illustrates the method of erection whereby the mast is assembled horizontally on the ground and then raised by means of a boom and tackle. As shown, one man can raise the 55′ mast, while on taller masts two men are desirable.

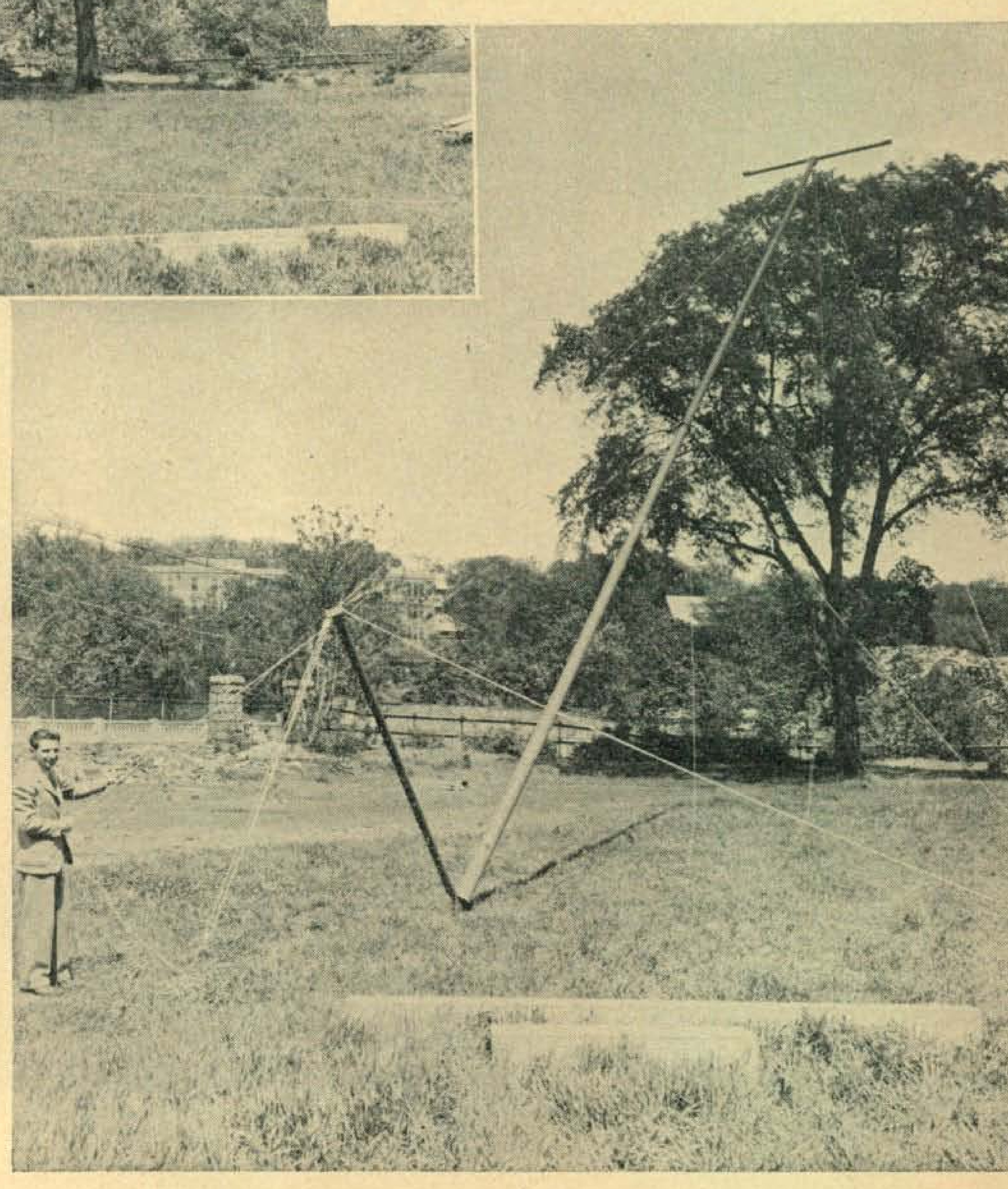


Fig. 2 (above). 55-foot mast with cross-arm

•

Fig. 4 (right). Method of erection. Mast is assembled horizontally on ground, then raised by means of boom and tackle.

OFFICER

[*Continued from page 9*]

work through serious interference and noise. On an aircraft this problem is intensified by engine ignition and vibration. The radio ham who did any operating on crowded amateur bands is more than a match for this condition. No amount of class room study and lecturing can give the man experience necessary to achieve this "know how."

Code speed doesn't have to be much over 25 words per minute to start, but accuracy must be 100%. Likewise, no class room lecture can adequately train a crewman to meet all the technical problems which can arise while in flight. The inherent curiosity of the amateur makes him better able to cope with unusual situations.

The Flight Radio Officer is an extremely attractive position. By far the majority of men now engaged in this work are amateurs. To be a ham is in itself an excellent recommendation. But this alone will not be any guarantee of a job. Those who have any idea of entering the field should set their course now and make every available effort to become fully acquainted with the requirements of the profession. It will be a big scramble after the war . . . but the amateur with a service record is already across some of the toughest obstacles!

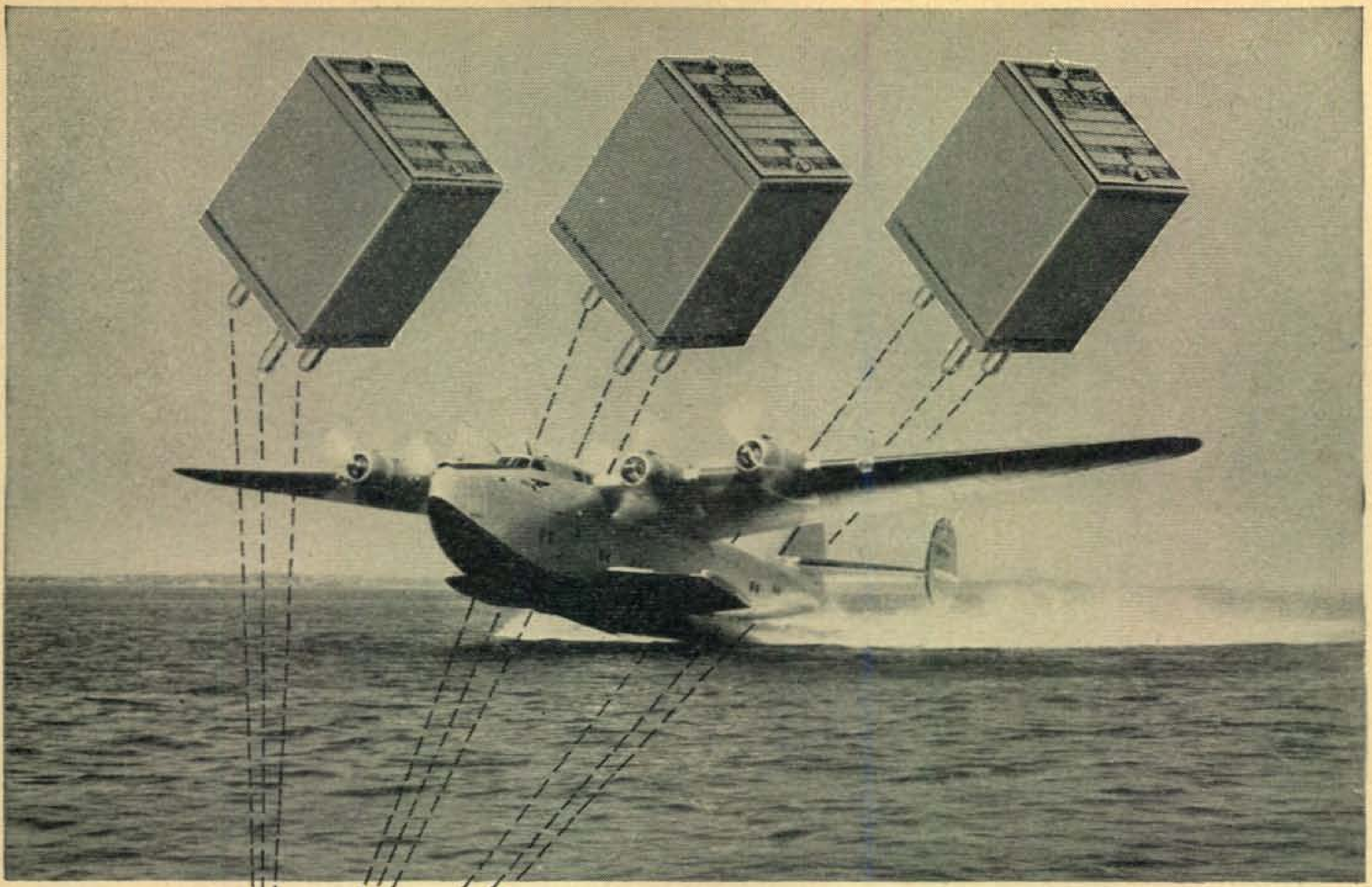
"Handie Talkie" and "Walkie Talkie"

There has been some confusion existing about the difference between the Motorola "Handie Talkie" and the "Walkie Talkie" and this, it is hoped, will help to clarify your ideas about both.

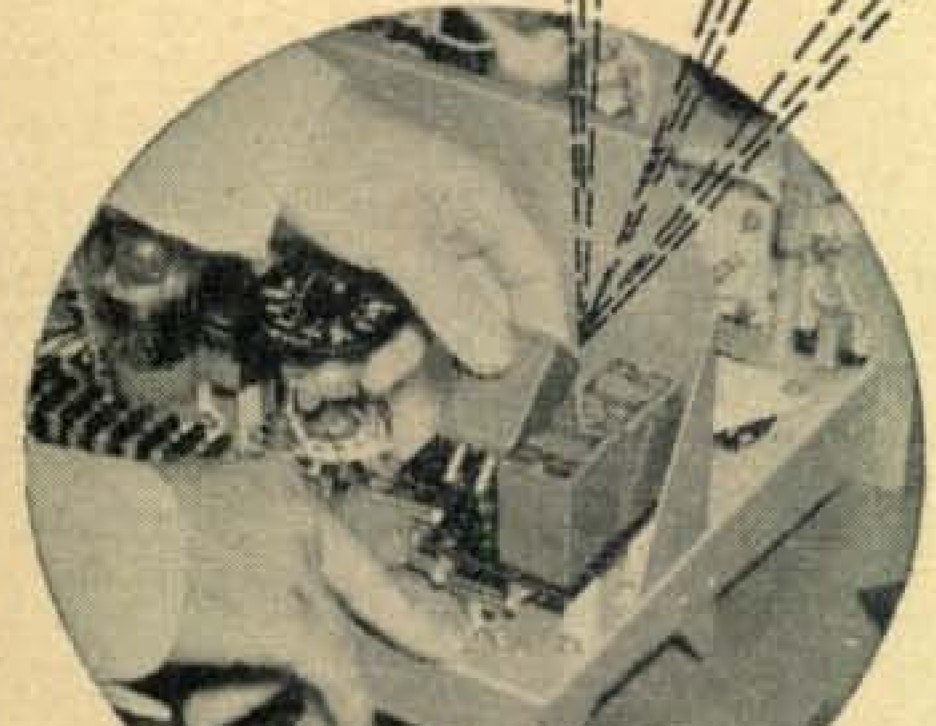
These two units are radio transmitters and receivers, but while they form a complete 2-way radio communication system, still they do not even look alike. This means that each one is a separate receiver and a separate transmitter complete within a portable housing. Both units are battery operated. Each unit has its own antenna which is used for both receiving and sending messages. From there on, here are the main differences:

The "Handie Talkie" is about the size of a narrow cracker box, 3 x 3 x 12 inches

[*Continued on page 36*]



BLILEY CRYSTALS, of course, fly with Pan American



Do more than before . . .
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Bliley *acid etched** crystals persistently show up wherever there is an important communications job to be done, such as the combination two-way telephone and telegraph and range finder systems of Pan American World Airways. In peace and in war Bliley crystals have flown millions of world-wide miles with their famous Clippers.

Bliley crystals are pre-conditioned for just such rugged assignments. In the Bliley Electric Company plant there is a large section where Bliley *acid etched** crystals receive their pedigree. Here each crystal gets "the works". Its activity and frequency are *proved* under tough laboratory created service conditions of altitude, humidity, temperature, immersion, shock and vibration.

But licking tough assignments is a tradition with Bliley engineers and craftsmen. This background of research and skill has been responsible for the distinguished record of Bliley Crystals in every field of radio communication. Whatever your crystal problem may be—specify Bliley.

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**Acid etching quartz crystals to frequency is a patented Bliley process. United States Patent No. 2,364,501*

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"Oh, she's OLD! Almost thirty!"

At twenty, thirty seems ancient.

At thirty, forty is distant middle age.

At forty, well, it'll be a long time before you're fifty.

The point is that ten years *ahead* always seems like a long time. Yet, actually it passes "before you know it" . . . and you find yourself face to face with problems, opportunities, needs, that once seemed very far in the future.

This is a good thing to remember today, when you buy War Bonds to speed the winning of the war.

In ten years—*only* ten years—those bonds will bring you back $4 for every $3 you put into them today.

Think of what that money may mean to you in 1955. An education for your children . . . a home . . . maybe even retirement to the place and the life of your heart's desire.

All this your War Bonds can mean to you . . . if you buy all you can today and hold them to maturity.

It won't be long till 1955. Not half as long as you think.

C Q

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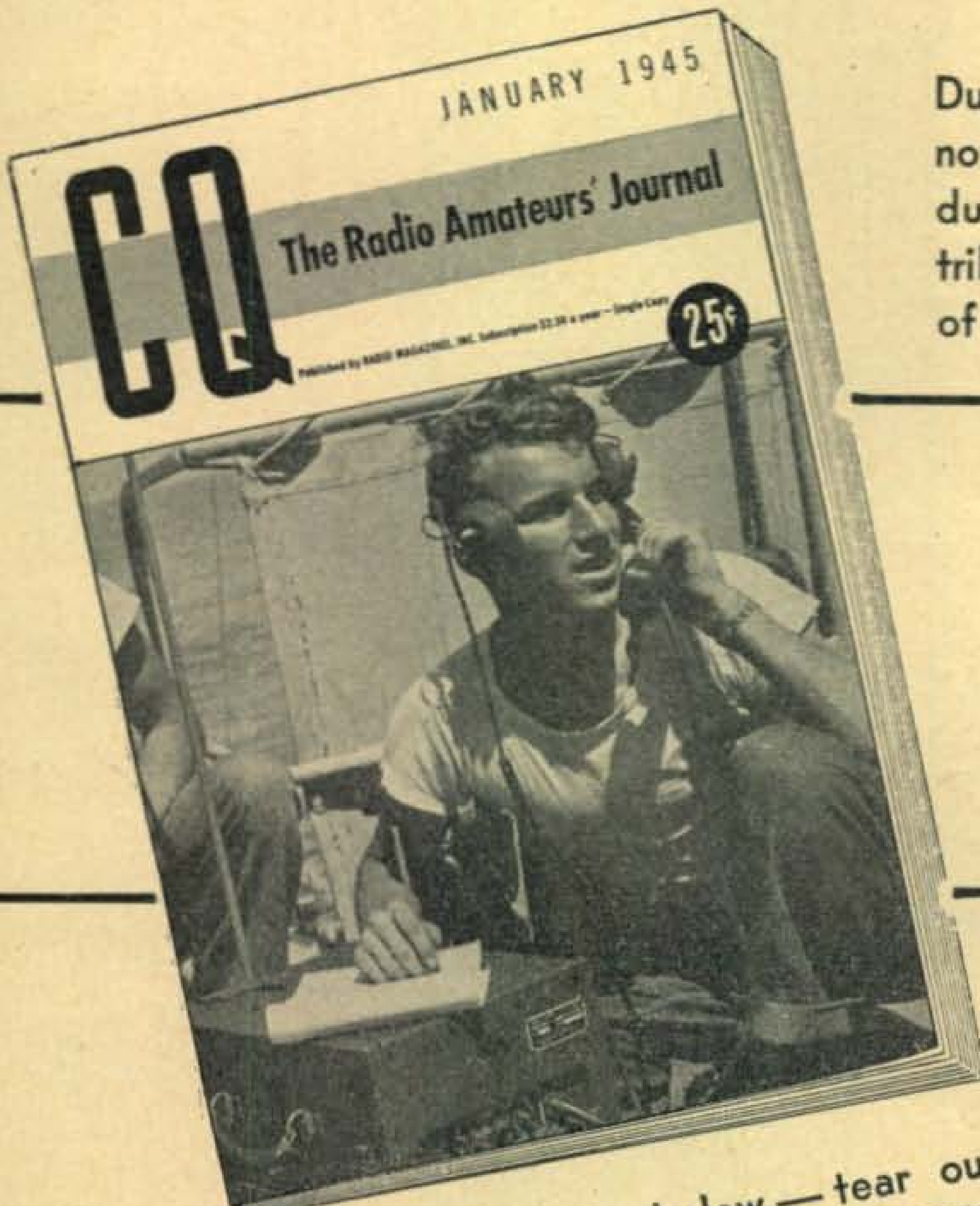

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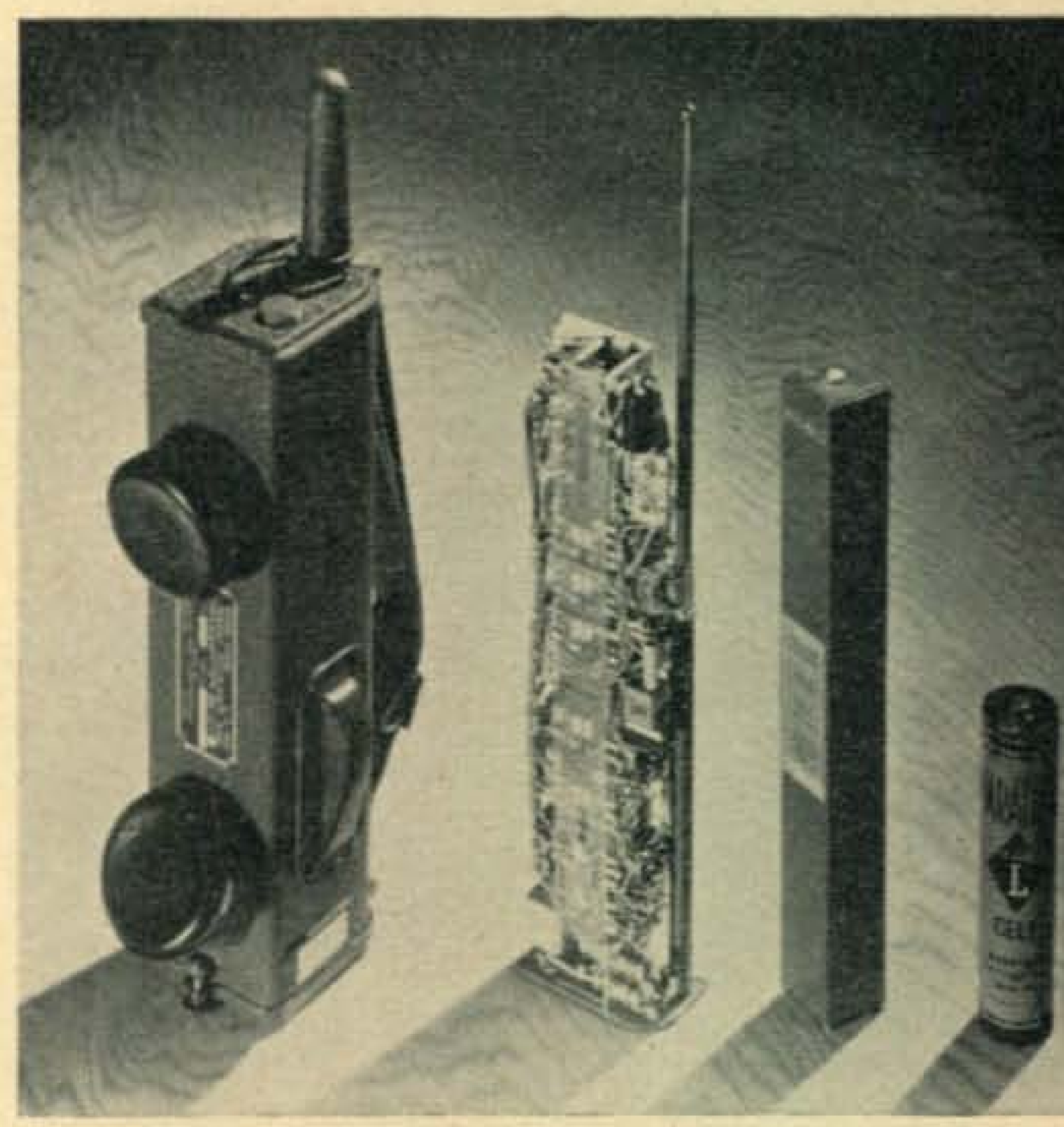
TALKIES

[*Continued from page 32*]



Type SCR-536 Handie-Talkie

long. The "Walkie Talkie" is about 17 inches high, twelve inches wide and about seven inches thick. The smaller "Handie Talkie" weighs a little over five pounds, and the larger "Walkie Talkie" about thirty-five pounds. The "Handie Talkie" is carried in the hand, the "Walkie Talkie" on the back. Both are developments of the Galvin Mfg. Corporation, Chicago.

The mouth and ear piece are attached to the "Handie Talkie" while the "Walkie Talkie" has connections into which are plugged the hand set (similar to a cradle type telephone set) and an earphone head set can also be attached. The range of the "Handie Talkie" is less than that of the more powerful "Walkie Talkie."

Both are 2-way radio communication sets which means that one person can broadcast and also listen to another who is broadcasting. When using, one person talks and the other listens. When through, the other person may talk while the first one listens. The reason for this is that the sets are tuned to the same wave length and if both were broadcasting at the same time, the waves would be jammed.

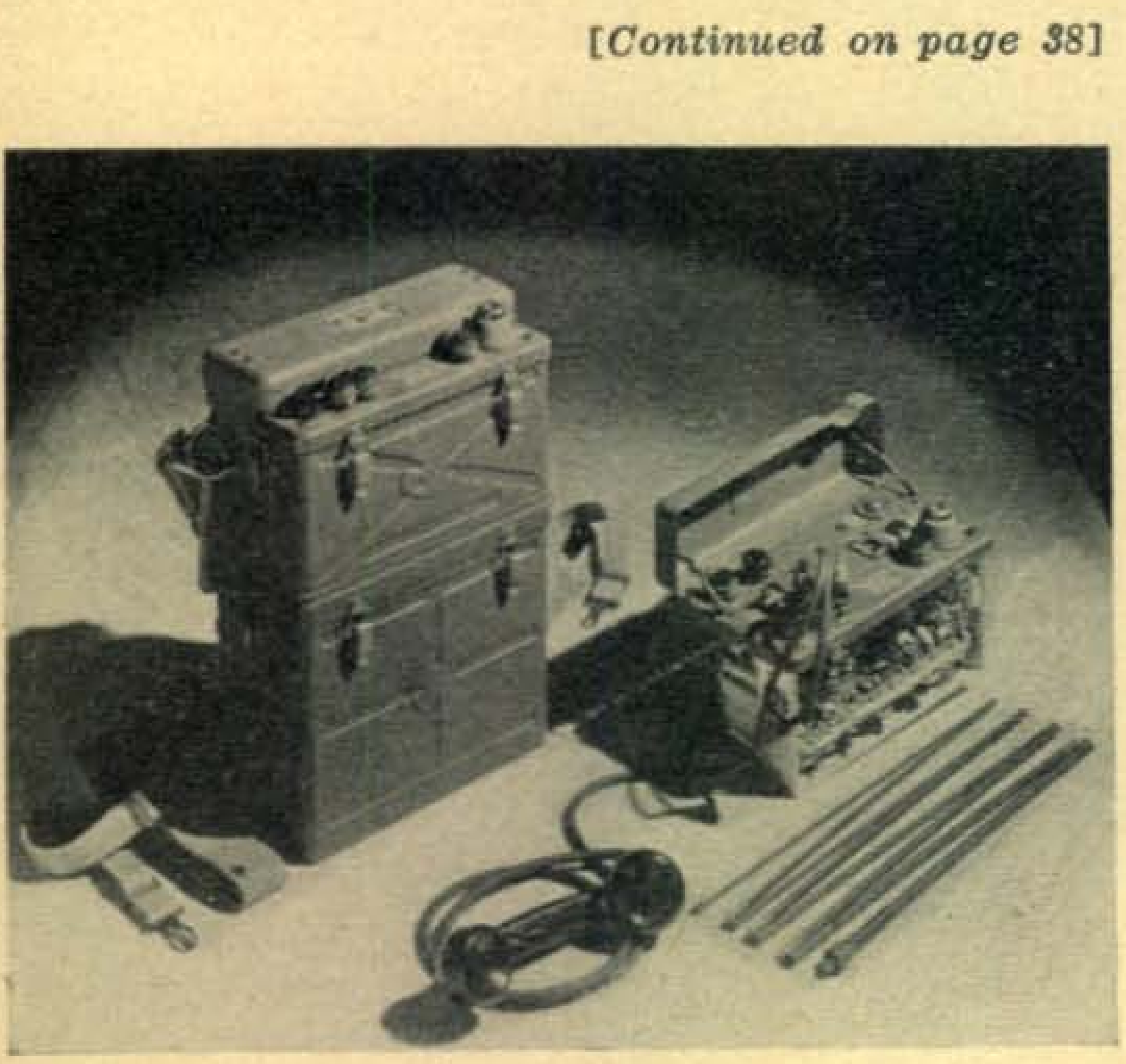
On the battle field, the "Handie Talkie" and the "Walkie Talkie" are assigned different wave lengths. Each pair or more of the sets also have their own wave lengths assigned for certain sections of the battle front so that the sets used by different companies or divisions will not interfere with each other. Wave lengths are changed frequently to avoid detection by the enemy.

Both sets are known as "fighting" radio sets because they are carried by soldiers into close proximity of the enemy. The easy portability of the "Handie Talkie" permits the carrier to use his hands for other purposes when required so that it is frequently carried by the first line of advancing infantry. The "Walkie Talkie" is also portable and is used more for front line command post communications than for actual front line activity though there have been cases recorded when the "Walkie Talkies" were used in advance of our front lines. It is also used frequently in landing operations. Hence their appropriate nicknames. "The Fightingest Radios in the War."

Other 2-way radios mounted in trucks, jeeps, automobiles, tanks, etc., are also used by the United States Signal Corps but these heavier units usually follow up the infantry advance and have far longer ranges than those of the "Handie Talkie" and "Walkie Talkie."

The Federal Communications Commission has proposed a Citizens' Radio-communication Service in the 460 to 470 megacycle band of the spectrum. According to a recent FCC press release, "Small portable radios may be used, for example, to estab-

[*Continued on page 38*]



Type SCR-300 Walkie Talkie

ZERO BIAS

[*Continued from page 5*]

makes radio transmitters tick—and eventually to amateur licenses.

The FCC does not recognize the Citizens Radio Service allocation as an amateur band. But in differentiating between commercial and non-commercial services, the CRS falls into the amateur category, and for those who want to employ it as such, it provides another set of frequencies in the ham spectra.

Equipping the Citizens Radio Service opens new manufacturing and conversion fields. Home-made equipment can be constructed only by experts, i.e., already licensed amateurs who may want to use this band. No walkie-talkie apparatus now being supplied to the armed forces, and which might become available through surplus distribution following the war, operates within the 460-470 megacycle allocation. However, these rigs could probably be converted (perhaps a lucrative service job) by the advanced ham.

[*Continued from page 37*]

lish a physicians' calling service, for communication to and from trucks and tractors operating in and around large plants, on farms and ranches, on board harbor and river craft, in mountain and swamp areas. Sportsmen and explorers can use them to maintain contact with camps. Department stores, dairies, laundries and other business organizations can use the service to communicate with their delivery vehicles."

However, there are many problems which must be overcome despite this liberal ruling of the FCC. "Handie Talkies" and "Walkie Talkies" are powered by batteries inasmuch as they are portable sets. Using such low power in such an ultra-high frequency will not permit communication over a very great distance—and long distances plus low cost is what is usually wanted by anyone using radio communication. Some day "Handie Talkies" and "Walkie Talkies" will be utilized for the Citizens' Radiocommunications Service. At first dry battery operated portable sets will not be used. Power will have to come from central stations or 6-volt wet batteries, but later on, when new tubes and stronger, longer-life batteries are developed, then there will be common use of "Handie Talkies" and "Walkie Talkies."

The "Handie Talkie" and "Walkie Talkie" have played a vital role of communications in the invasion and the success of the invasion was enhanced by the fact that General Eisenhower's United Nations forces had welded together communications equipment and facilities of the most modern type which are unrivaled in the history of warfare.

The amphibious landing forces in the first assault waves established radio communications as soon as possible to link up the various beachhead units. As the troops hit the beaches of northern France, they fanned out quickly to seek cover and the Signal Corps units of each shore party carried "Handie Talkie" and "Walkie Talike" radio sets. The shock troops who landed on the French beachheads after the Naval bombardment and Air Force bombing also carried "Handie Talkie" and "Walkie Talkie" sets to keep in contact with each other and with the divisional headquarters aboard the key ship of their Naval force.

WWV

[Continued from page 28]

5 megacycles in daytime. But only the 440 2. F. modulates on 5 megacycles from 7:00 P. M. to 7:00 A. M., E. W. T., and the 2.5-megacycle frequency. A pulse of 0.005-second duration occures at intervals of precisely one second on all carrier frequencies. The pulse consists of five cycles, each of 0.001-second duration, and is heard as a tick when listening to the broadcast. It provides a useful standard of time interval, for purposes of physical measurements, and may be used as an accurate time signal. On the 59th second of every minute the pulse is omitted.

Code and Voice Announcements

The audio frequencies are interrupted precisely on the hour and each five minutes thereafter; after an interval of exactly one minute they are resumed. This one-minute pause is provided for station announcement and the checking of radio-frequency measurements free from the presence of the audio frequencies. The announcement of the station call letters (WMV) is in telegraphic code (• — — • — — • • • — twice), except at the hour and half hour when a detailed announcement is given by voice.

The accuracy of all the frequencies, radio and audio, is better than a part in 10,000,000. Propagation effects may result at times in slight fluctuations in the audio frequencies. However, the average frequency received is as accurate as that transmitted. The time interval marked by the pulse every second is accurate to 0.00001 second. The 1-minute, 4-minute, and 5-minute intervals, synchronized with the seconds pulses and marked by the beginning or ending of the periods when the audio frequencies are off, are accurate to one part in 10,000,000.

World Wide Coverage

The beginnings of the periods when the audio frequencies are off are so synchronized with the basic time service of the U. S. Naval Observatory that they mark accurately the hour and the successive 5-minute periods.

Of the radio frequencies on the air at a given time, the lowest provides service to short distances, and the highest to great distances. In general reliable reception is possible at all times throughout the United States the North Atlantic Ocean, and fair signals are heard throughout the world, (in accordance with the usual day and night, seasonal and sunspot variations).

Information on how to receive and utilize this service is given in the Bureau's Letter Circular, "Methods of using standard frequencies broadcast by radio," obtainable on request. The Bureau welcomes reports of difficulties, methods of use, or special applications of the service. Correspondence should be addressed National Bureau of Standards, Washington, D. C.

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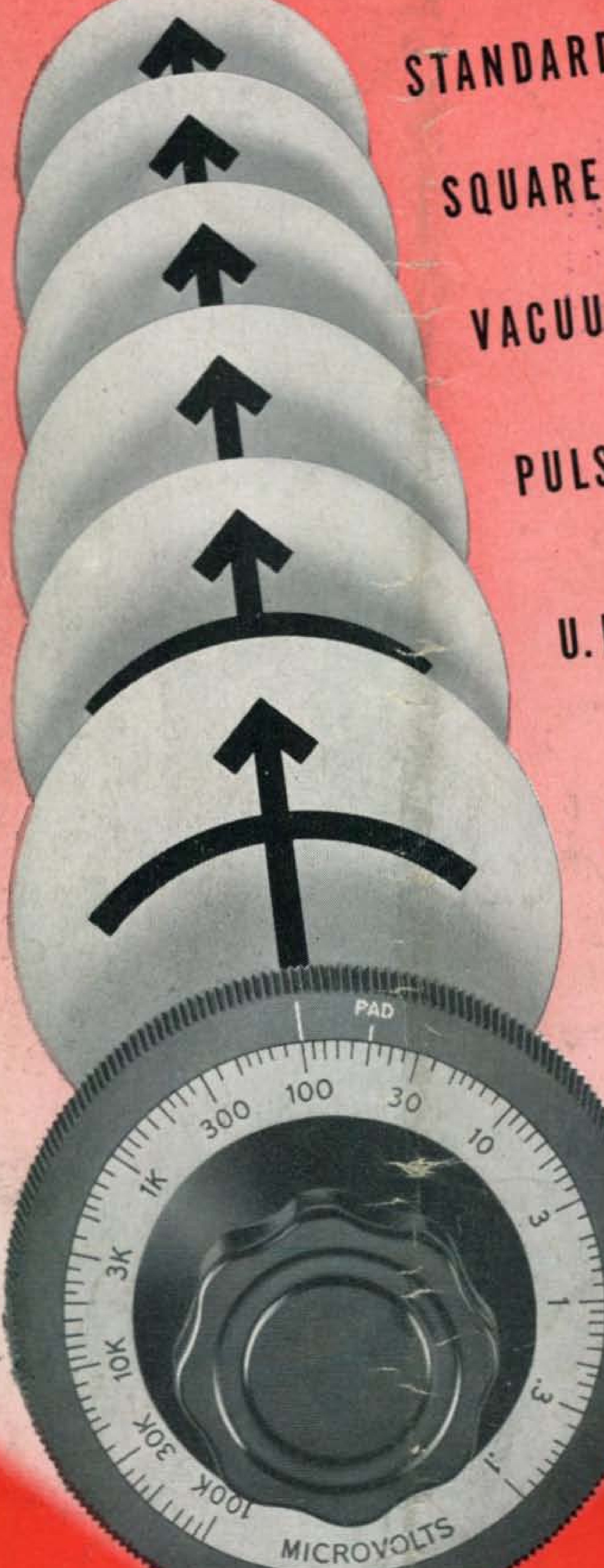

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