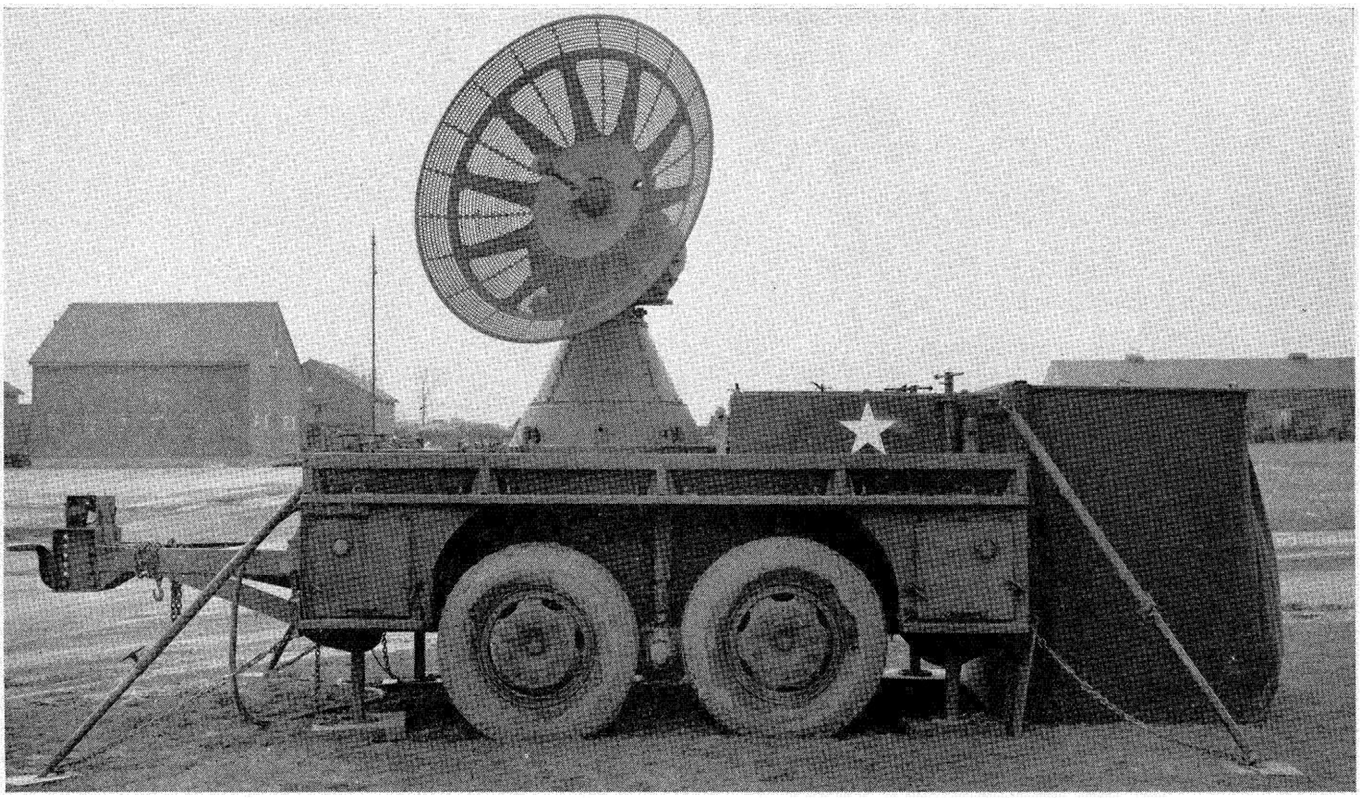


A radar set designed for fire control problems. The SCR 784. This unit is highly mobile and was intended for use on beach heads.

Radar-Military Weapon or Civilian Lifesaver?

by W. H. PICKERING

RADAR to the moon — two and a half seconds for the round trip: is this an indication of the peacetime applications of radar, or may we expect some more immediate and practical benefits from the vast development of radar by all branches of the military services? Before answering this question, let us review some of the facts about radar which have recently been released to the public.

The basic idea of a radar system is well known. It consists essentially of a radio transmitter which sends out a beam of electro-magnetic energy i.e. radio waves. If the beam strikes an object, some of the energy will be reflected or scattered and, in general, some energy will return to the sender. A suitable receiver then serves to indicate the presence of the reflecting object. If the time for the round trip of the radio waves can be measured, the distance to the object is known, and if the beam is sharply defined, the direction of the object is likewise known. To measure the travel time of the waves, a sharp pulse of energy is transmitted and the time required for the echo to return is measured on a cathode ray oscilloscope. Since the waves travel at 186,000 miles a second, they cover about 1,000 feet in a microsecond, so that an echo occurring one microsecond after the pulse represents an object 500 feet distant. Therefore, if distances are to be measured to an accuracy of say 50 feet, time must be measured to an accuracy of one ten millionth of a second.

In order to get a sharply defined beam of energy it is necessary to use a transmitting antenna which is much greater than a wave length in its dimensions. This phenomenon is exactly analogous to the diffraction of light through a pin hole. If the hole is so small as to be comparable in its dimensions to the wave length of the light, then light waves passing through the hole are not restrained to a geometrical beam but spread out over a large area. In optics we are accustomed to think in terms of sharp beams because the wave length of the light is usually much smaller than the dimensions of the apparatus. However, with radio waves, the opposite situation usually holds and we think of the waves as spreading out in all directions. But if the antenna is large compared with the wave length, the radio energy may be constrained into a narrow beam.

If we ask what range of detection may be expected with a radar set, the answer is obviously dependent on the magnitude of the reflected signal. However, it is worth noting that the energy received back at the sending station from a given target will decrease at least as fast as the inverse fourth power of the distance to the target. Therefore, in order to double the range, the transmitted power must be increased 16 times. The implication is that a successful radar set must use every possible artifice to increase its sensitivity. The transmitted power must be very large, the antenna system must be large and efficient, the receiver must be very sensitive.

Military Applications of Radar

A wide variety of radar sets was developed during the war. This was partly because of the rapid development of the art, but principally because of the diverse uses to which radar was put. To sum these in broad outline, we have the following:

Search radars — designed to locate ships or airplanes at large distances. The range accuracy will probably be good, the bearing accuracy not very good, because if too sharp a beam is employed, the distant object may be overlooked.

Fire control radars — designed to give the highest possible precision of both range and bearing. If these are used for aircraft targets, tracking of the target may be at least partially automatic. Information from these sets will be fed into a computing mechanism which operates the artillery weapons.

Airborne radars — designed to be as light and compact as possible, used for surface or aircraft search.

Bombing radars — designed to give a map of the terrain below the plane in order to assist the bombardier in locating his target.

Each of these categories may be subdivided into a number of types, depending upon the particular use for which the radar is designed. Thus we have land based and ship based radars, we have several different methods of presenting the radar data, we have long range and short range sets, air search and surface search, all adding to the multiplicity of types.

In addition to the applications named above, the radar principle has been applied to a number of other devices, such as:

Absolute altimeter — a means for determining the altitude of an airplane above the ground by determining the time taken for a radio signal to travel from plane to ground and return.

Radar beacon — a transmitter which will return a coded signal when properly interrogated by a radar transmitter. In this way an airplane with a radar set can, for example, obtain the bearing and distance to some known point on the map at which the beacon is located.

Ground Control Approach (GCA) — a means by which an officer at an airport is able to "talk down" an airplane landing blind. The airport is provided with a radar set giving an accurate picture of all traffic in the vicinity. By watching the plane on the radar receivers the officer can instruct the pilot as to the correct maneuvers to make a landing.

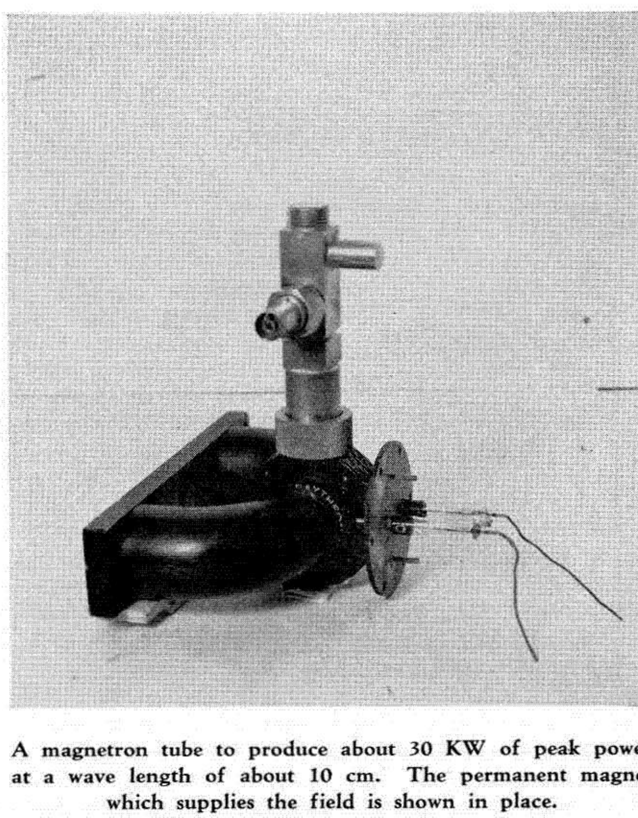
Loran — a technique for long range navigation which uses a measurement of the time difference required for radio signals to come from two known transmitting staions. The locus of points having a constant time difference, or path difference, is a hyperbola with the two transmitters at the foci. By observing such time differences from two pairs of stations, the receiver can be located at the intersection of two hyperbolas. A chart provided with the two families of hyperbolas will then give the position of the receiver. This technique has been found to give rapid and reliable "fixes" out to ranges of several hundred miles.

Shoran — a short range navigation scheme of the same nature as Loran, except that the transmitter is on the ship or plane and two fixed receivers at known locations repeat the signal back to the sending point. . Accuracies of the order of 50 feet are attainable to distances of better than 100 miles.

Peacetime Radar

It is apparent from this list of radar devices that the peacetime applications of radar will be in the field of navigation. Radar can be used to solve almost every navigational problem. Ships and planes over the ocean several hundred miles from land can obtain their position from Loran with a precision and speed rarely attainable by celestial observations, and in weather conditions that make celestial observations impossible. Ordinary radar will allow a ship to travel at full speed through fog, even in a crowded harbor. With radar the ship has eyes which penetrate fog and storm and night, albeit not with the detail seen by the human eye in clear weather, yet with sufficient clarity to locate and identify the surroundings. Similarly a plane equipped with radar can determine its position and altitude, and thus fly through fog and darkness to its destination.

It must be conceded that radar is more satisfactory when used over sea than over land. At sea there are no targets to give reflections except the ships or planes or icebergs which the radar operator is seeking. Therefore, his screen is clear of extraneous information and he can see the desired picture sharply and unambiguously. On the other hand, a radar signal travelling over land may be reflected by hills or trees or buildings, so that the radar picture is cluttered up with a great many reflections which fre-

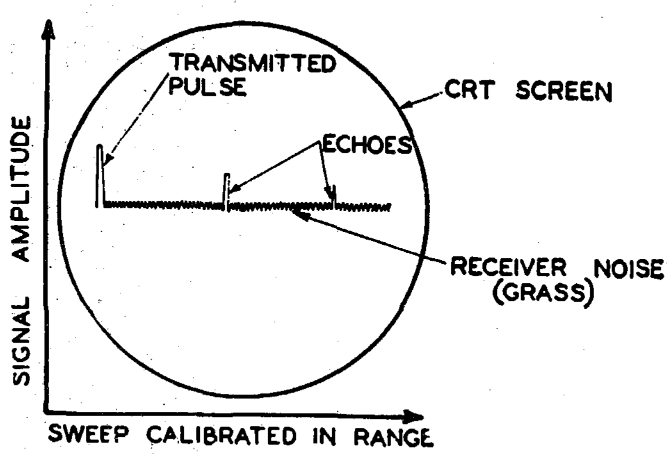


A magnetron tube to produce about 30 KW of peak power at a wave length of about 10 cm. The permanent magnet which supplies the field is shown in place.

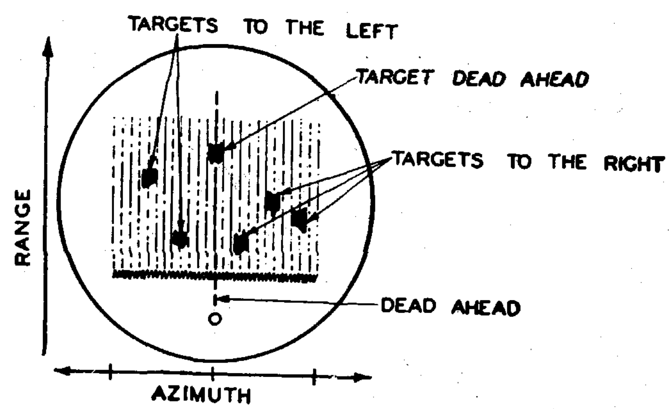
quently make it very difficult to interpret. However, water, and such demarcations usually serve to identify and orient the picture. In passing we may note that water does not give a reflection on the radar screen, because it acts like a horizontal mirror and the signals from the transmitter are reflected away from it. No energy is reflected back to the receiver unless the water is directly beneath the radar set.

For this reason it is probable that the first peacetime applications of radar will be for marine use. We can visualize ships equipped with relatively simple, short range radar sets, navigating safely through crowded waters in spite of fog or darkness. We can also visualize aircraft on long overwater flights, using Loran to navigate to their destination. With Loran the speed and accuracy with which a location can be calculated are such that even in a plane flying at four or five miles a minute the navigator can always find his exact position. Loran signals can now be heard over large portions of the Atlantic and Pacific oceans, and it is probable that within a few years all points on the earth's surface will be in the range of Loran transmitters. These signals, of course, can be used for the precision navigation of surface vessels also; however, because of the slow speed of ships, not so much importance is attached to obtaining the frequent and accurate fixes necessary for aerial navigation and obtained from Loran. This does not mean that Loran will not be used for surface navigation. It has definite advantages of simplicity in operation over conventional celestial navigation, and of operation in weather which can keep the celestial navigator blind for days on end. It is not too much to hope that someday the system will be completely automatic, so that, by simply tuning in a particular set of transmitting stations, the navigator may cause the co-ordinates of the ship's position to appear on two dials before him. Even before this day arrives, Loran will almost certainly see extensive use on shipboard. Recently the first commercial Loran installation for maritime use was publicly demonstrated in New York.

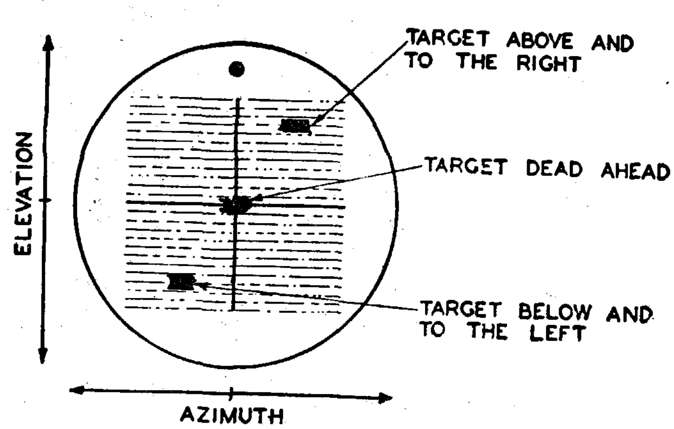
The radar applications so far discussed are sufficient to solve the navigational problems of a ship. An airplane, however, has a more complicated problem to solve. It needs an accurate navigational aid for landing, which must operate over land rather than sea, and it needs a third dimension, namely altitude, at all times, and during landing this third dimension must be exceedingly accurate. Although military radars were used for blind bombing operations, it is unlikely that such equipment will be used in everyday commercial operations. It is expensive and heavy, and the problem is better solved in other



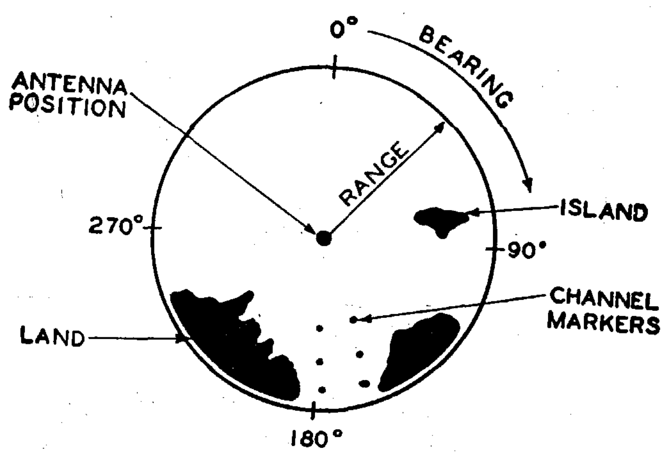
Type A-scan presentation



Type B-scan presentation



Type C-scan presentation



Type PPI-scan presentation

Four of the principal methods of target indication on cathode ray tube screens used in conventional radar sets.

ways. Existing radio beams and beacons will bring an airplane safely to the vicinity of an airport, so that it only remains to get it safely on the ground. The Army development of GCA or ground control approach would appear to be the best solution to the problem. It requires an elaborate radar installation at the airport, but only the usual radio receiver in the plane. By watching the plane on the radar screens the traffic controller on the ground can give the proper instructions on the radio to bring him in to a safe landing. The system requires, of course, considerable confidence on the part of the pilot in the ability and judgment of the man on the ground.

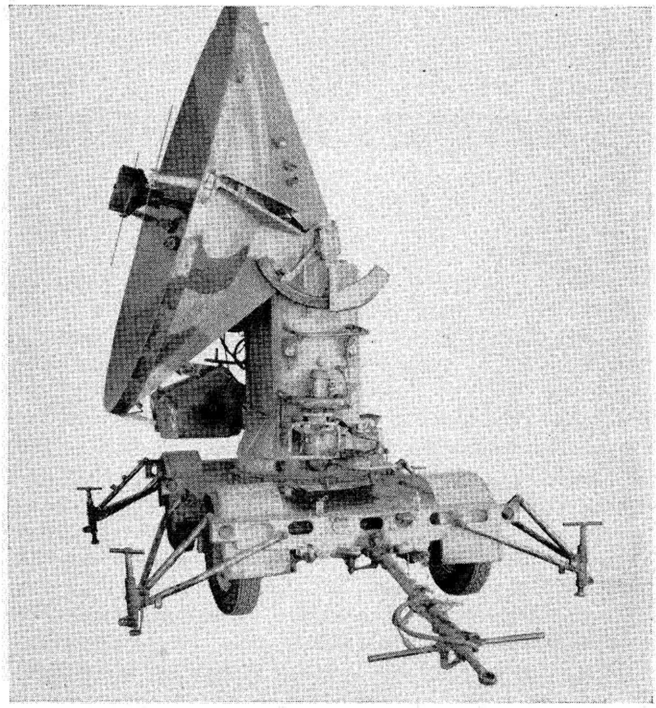
An alternative scheme has been recently proposed to give the pilot greater freedom of choice in his movements and to solve the problems which very heavy traffic would impose on the voice radio circuit.* This, known as "Teleran", consists of adding a television transmitter to the ground installation and a television receiver to the plane. The pilot would then see the radar information for himself, and furthermore additional factors, such as weather, etc., could be added as a simple printed sheet televised over the same circuit. Such a system will probably not be necessary for some years, but is an interesting example of what is technically possible even at this time.

The problem of determining the altitude of a plane is intimately connected with that of avoiding collisions with other planes. The radar altimeter mentioned above is obviously adaptable to peacetime use. However, it would be desirable if its use could be extended to give some sort of automatic warning of an impending collision. Technically this is possible, and, if increasing air traffic justifies its use, we may expect to see such an automatic collision indicator developed.

The Radar Picture

In considering the peacetime applications of radar, the question of the form of the presentation of the data is of great importance. For military uses, several different systems have been employed. Unfortunately there is no system which is exactly the ideal, namely, a picture equivalent to that obtained by looking through a telescope on an unusually clear day; however, there is one which comes close to this. It is the so-called plan-position-indicator PPI. An operator using a PPI scope sees a circular picture which is actually a radar map of his surroundings out to a radius of say 50 miles, with the radar set at the center of the picture. Any ships or airplanes within this range will appear as bright dots at the proper points on the map. Land will appear as a conglomeration of bright spots, showing a more or less sharp outline of the shore. The interpretation of such a map-like picture is very simple so that it can be quickly learned by relatively unskilled personnel. It is to be expected that the PPI will be almost universally used on peacetime, navigational radars. It will be provided with a range switch to change the scale of the map, and possibly with an arrangement to show only one sector of the map and to enlarge that sector. Indicated on the map will be geographic north and the direction in which the ship is travelling. There will also be range markers, consisting of circles at say five mile intervals. With this map, and a little training, it is obvious that radar navigation is almost as satisfactory as navigating from the bridge on a clear day. As radar techniques improve, the sharpness and detail of the PPI picture will improve and even the untrained novice will be able to distinguish between the tug boats and the Queen Mary.

*"The Teleran Proposal", P. J. Herbst, I. Wolff, D. Ewing and L. F. Jones, **Electronics,** February, 1946.



View of the German Wurzburg radar.

The other systems of data presentation have been designed primarily for obtaining great accuracy in range. Although this is of prime military importance, it is not very significant for navigational radar. Two peacetime applications requiring range accuracy would be airport traffic control and the radar altimeter. The first will of necessity be an elaborate and expensive installation, requiring highly trained personnel. The second must present data to untrained personnel and provide an easy interpretation.

The principle of radar ranging is of course the timing of the arrival of the radar echo. In the simplest form, a spot starts moving across a cathode ray oscilloscope tube at the instant at which the pulse is transmitted. The returning echo shows as a "pip" on the trace, and the distance between the pip and the start of the trace, together with a knowledge of the velocity of the spot, enables one to calculate the time, and hence the distance to the target. For good accuracy the length of the trace should be as great as possible. One method of utilizing the oscilloscope screen to a greater extent is to have a circular trace with radial deflections. The length of such a trace is about three times that of a single straight trace on the same tube. Such a circular trace is very convenient for an altimeter indicator, since it shows a pip which moves around the screen in much the same way as a pointer on a conventional instrument. With a suitable scale the altitude can be read directly.

(Continued on page 11)

only in the year of actual abandonment.[29] It is distinguishable from depreciation, in which it is considered that the asset gradually wastes away during its expected life, and from obsolescence, in which the expected life in shortened but not completely terminated.

It is settled that the deduction for loss by abandonment applies to both patents[30] and patent rights.[31] A question has arisen as to whether there may be some residual value to the abandoned patent, or whether there must be a complete uselessness before the loss may be allowed.[32] Early cases have expressed the view that there can be no residual value.[33] However, the present Treasury Department Regulations appear to contemplate an abandonment loss where there may yet be some salvage or scrap value to the patent abandoned.[34] The question becomes acute where a patent is "sold" for its scrap or salvage value. Is this a sale or exchange, such that, if appropriate, the capital loss limitations apply? Or is this an abandonment of all but the residual value, such that a full loss, less the salvage value recovered, is deductible? There is no clear-cut answer to this question, although it would appear to be a fully deductible loss where the taxpayer writes down the depreciated cost of the patent on his books to its present estimated salvage value, and in a separate—though almost simultaneous—transaction, sells it for its scrap or salvage value.[35]

IV Conclusion

Tax avoidance, which the author likes to refer to as tax "savings", is a legitimate realm within which the ingenuity of an individual may be translated into actual dollars. Particularly with respect to installment sales and compensation for work performed on an invention for a period of 36 months or more, a taxpayer has the opportunity to effect tax savings for himself which should not be overlooked.

1. Buck, "Income Tax Evasion and Avoidance; Some General Considerations," 25 Georgetown, L. J. 863 (1937); Angell, "Tax Evasion and Tax Avoidance", 38 Co. L. R. 80 (1938)
2. Addressograph-Multigraph Corp., TC Memo Op., Dec. 14, 387 (M); Claude Neon Ligts, Ins., 35 BTA 424; Buffalo Forge Co., 5 BTA 947; Gillian Mfg. Co., 1 BTA 967
3. Globe Construction Co., 25 BTA 146.
4. Internal Revenue Code Sec. 23 (e) and (f).
5. Regulations 111, Sec. 29.23 (1)—7.
6. Hazeltine Corp. v. Com'r., 89 F. (2) 513 (CCA 3rd, 1937).
7. Twin Disc Clutch Co., 2 BTA 1327
8. National Piano Mfg. Co., 11 BTA 46
9. Deltox Grass Rug Co., 7 BTA 811; Burke Electric Co., 5 BTA 553.
10. Internal Revenue Code, Sec. 114 (a) and 113 (a) (5).
11. Regulations 111, Sec. 29.23 (1)—6; Hazeltine Corp v. Com'r., **supra** note 5; O'Neill Mach. Co., 9 BTA 567.
12. A.R.R. 98, 2 C.B. 105; cf Allen & Co., TC Memo Op., Dec. 13,216(M).
13. Meyer & Bros. Co., 4 BTA 481.
14. **supra**, Note. 13.
15. Addressograph-Multigraph Corp., **supra**, note 2.
16. Becker Bros. v US, 7 F. (2d) 3 (CCA 2nd, 1925).
17. Peck, Stow & Wilcox Co., 12 BTA 569; Safe Guard Check Writer Corp., 10 BTA 1262.
18. Ward v. US, 32 F. Suup. 743 (1940).
19. Triplex Safety Glass Co. of N. A. v. Latchum, 131 F. (2d) 1023 (CCA 3rd, 1943; W. W. Sly Mfg. Co., 24 BTA 65.
20. Hyatt Roller Bearing Co. v. US, 43 F (2d) 1008 (Ct. of Claims, 1930).
21. Internal Revenue Code, Sec. 117 (a).
22. Myers 6 T. C. No. 32; Diescher, 36 BTA 832; GMC 21507, 1939-2 CB 189; I. T. 3310, 1939-2 CB 190; Bureau Letter Jan. 6, 1944.
23. Internal Revenue Code, Sec. 44.
24. I. T. 3773, Int. Rev. Bull. No. 24 (Dec. 1945).
25. Internal Revenue Code, Sec. 117.
26. Regulations 111, Sec. 29.23 (e)-3.
27. Mertens, "Law of Federal Income Taxations," Sec. 28.19
28. Regulations 111, Sec. 29.23 (e)-3.
29. Liberty Baking Co. v. Heiner, 37 F. (2d) 703 (CCA 3rd, 1930).
30. Connecticut National Pavements, Inc., 3 BTA 1124.
31. **supra**, note 29.
32. See discussion Mertens, **supra**, note 26, Sec. 28.17; CCH Standard Federal Tax Reporter, Par. 197.01.
33. Consolidated Window Glass Co., 1 BTA 365.
34. Regulations 111, Sec. 29.23 (e)-3.
35. **supra**, note 31.

Radar--Military Weapon or Civilian Life Saver?

(Continued from page 7)

A radar installation used for airport traffic control must present the equivalent of a three-dimensional picture of the airport and its surroundings. This will obviously require at least two radar plots, one of which could be a PPI and the other a plot of height versus range for the planes in some given direction. The Teleran system mentioned above reduces the problem to a two-dimensional plot of the PPI type, but provides a separate plot for each altitude zone.

Commercial Radar

Peacetime radar sets will obviously be built to different specifications from those of military radar. In both cases reliability is certainly of prime importance, but cost, which is of negligible importance to the military, becomes vastly more significant in peace. Furthermore, if peacetime radar is to be widely used, the sets must be designed so that operation does not require a highly skilled technician, or frequent maintenance.

If radar is to be used at all it might justify itself economically. Equipment can be designed and built for the applications discussed above, and these should prove numerous enough and important enough to warrant the expense involved. For example, consider radar for ship navigation. A commercial version has already been demonstrated. Its use is justified for any ship where navigation in crowded waters is necessary, provided the value of the cargo is such as to put a premium on prompt delivery. With radar, collisions can be avoided and the ship go through on schedule, in spite of adverse conditions. One application already suggested is for shipping on the Great Lakes. It might be thought that tugboats and ferry boats in a harbor such as New York would be a fruitful market for radar. However, it is doubtful if the expense is warranted in these cases. On the other hand, overseas shipping, particularly express liners or freighters, could well use radar to advantage in navigating up the harbor.

Consider Loran designed for shipboard use. This is important as an adjunct to the conventional methods of navigation. It should not be considered as replacing them entirely, for the obvious reason that a failure of the electronic equipment would leave the ship completely blind. Shipping using the equipment would then consist of express liners and freighters, travelling in northern waters, for example, where storms and fog make celestial navigation difficult.

(Continued on page 12)

Radar--Military Weapon or Civilian Life Saver?

(continued from page 11)

As far as airborne radar is concerned, it has already been indicated that a search type of radar is neither necessary nor desirable, expect perhaps in the simple form of a collision indicator. What is more important is the radar, or radio, altimeter with Loran for trans-oceanic flying. Absolute altimeters could well be standard equipment on all commercial planes, and, in fact, developments in this direction had started before the war. Loran is almost a necessity for long flights over the ocean. Successful all-weather flying needs some sort of radar equipment in the plane, or, more probably, GCA equipment at all major airports. It is hardly necessary to point out that in commercial flying, every pound of equipment added to the plane is a matter of deep concern to the operators. Therefore, future developments must be in the direction of simplifying and combining existing devices rather than adding new ones to satisfy every whim of the gadgeteer.

As an example of a commercial search radar for ships, the following is a brief description of a General Electric design.* The set is in three units: antenna, console, and motor alternator. The antenna is a truncated paraboloid of revolution made up of parallel metal slats and rotated by a small motor at 10 rpm. It is about three and one-half feet wide and one and one-half feet high, and will normally be mounted as high as possible on the ship. The console contains the transmitter, receiver, cathode ray tube, and the auxiliary equipment. Seven controls are needed for normal operation. The cathode ray tube presents a PPI picture. A choice of three ranges, two, six, and 30 miles, is available. The console is designed for easy servicing, with the circuits on removable chassis. It will be located on the bridge or in the chart room. The motor-alternator provides the necessary AC power to the equipment.

This radar set is reported to have been used over a period of six months and to have been operated successfully by persons with a wide variation of technical skill.

*"Maritime Radar for Peacetime Use." L. H. Lynn and O. H. Winn, **American Institute of Electrical Engineers Technical Paper 46-47**,—January 1946.

C. I. T. NEWS

INAUGURATION OF PRESIDENT DUBRIDGE PLANNED FOR NOVEMBER

CALIFORNIA Institute's first presidential inauguration will take place on November 12, when Dr. Lee A. DuBridge will formally take office as president. To be held in Pasadena's Civic Auditorium on Tuesday at 3:00 p. m., the event will be one of utmost importance to those having any connections with the Institute.

Invited are the alumni, the student body, the board of trustees, faculty, associates, and friends of C.I.T.

Academic regalia will prevail, and the procession should be colorful with representatives of schools, colleges and universities from all parts of the country participating.

Speakers at the actual inauguration will be James R. Page, chairman of the Board of Trustees, Karl Compton, Ph.D., LLD., D.Sc., president of the Massachusets Institute of Technology; Robert A. Millikan, Ph.D., LL.D., D.Sc., vice president of Board of Trustees and former chairman of the Executive Council, of California Institute of Technology; and Lee A. DuBridge, Ph.D., D.Sc., incoming president of the California Institute of Technology.

Also expected to be present at the ceremony are scientists and academic administrators including Alan Valentine, president of the University of Rochester, where Dr. DuBridge formerly headed the physics department, and which recently lost three men from its staff to college presidencies, six in the past 10 years; Vannevar Bush, president of the Carnegie Institute, and director of the Office of Scientific Research and Development; and Frank B. Jewett, president of the National Academy of Science and former president of the Bell Telephone Laboratories.

Further events of the inaugural week are a luncheon in the Athenaeum for visiting academic representatives, a dinner in Los Angeles on the day following the Inauguration, and a reception at the Athenaeum following the ceremony for faculty, trustees, and the alumni.

BIOLOGY DEPARTMENT RECEIVES ENDOWMENT IN KERCKHOFF WILL

LAST of the gifts which the late William G. Kerckhoff made to the Institute was the amount stipulated in clause XX of his will. This ". . . will bequeath $400,000 to the Institute to be known as the WILLIAM G. AND LOUISE E. KERCKHOFF ENDOWMENT FUND, the income thereof to be used to support, and for the purposes of the William G. Kerckhoff Laboratories of the Biological Sciences."

In 1928 the Kerckhoffs gave $1,000,000 to the Institute for the purpose of creating facilities for biological research. Most of this amount was used for the several units of C. I. T.'s now extensive and well-equipped laboratories.

The west section of the Kerckhoff Laboratory was completed *in 1930* at a cost of *$276,680.86. Nine* years later the building was enlarged to its present size. This addition cost $392,159.82. Also included in the Institute's laboratory system was the experimental farm in Arcadia, where corn genetics experiments are now being carried out, the William G. Kerckhoff Marine Biological Laboratories at Corona del Mar, and the Plant Physiology Laboratory and first greenhouse, located on the corner of San Pasqual street and Michigan avenue opposite the Institute.

The remainder of the original $1,000,000 and the interest accrued, with the recent endowment will be available for further pursuit of the biological sciences. This generosity of the Kerckhoffs has made possible