RADIO SCIENCE

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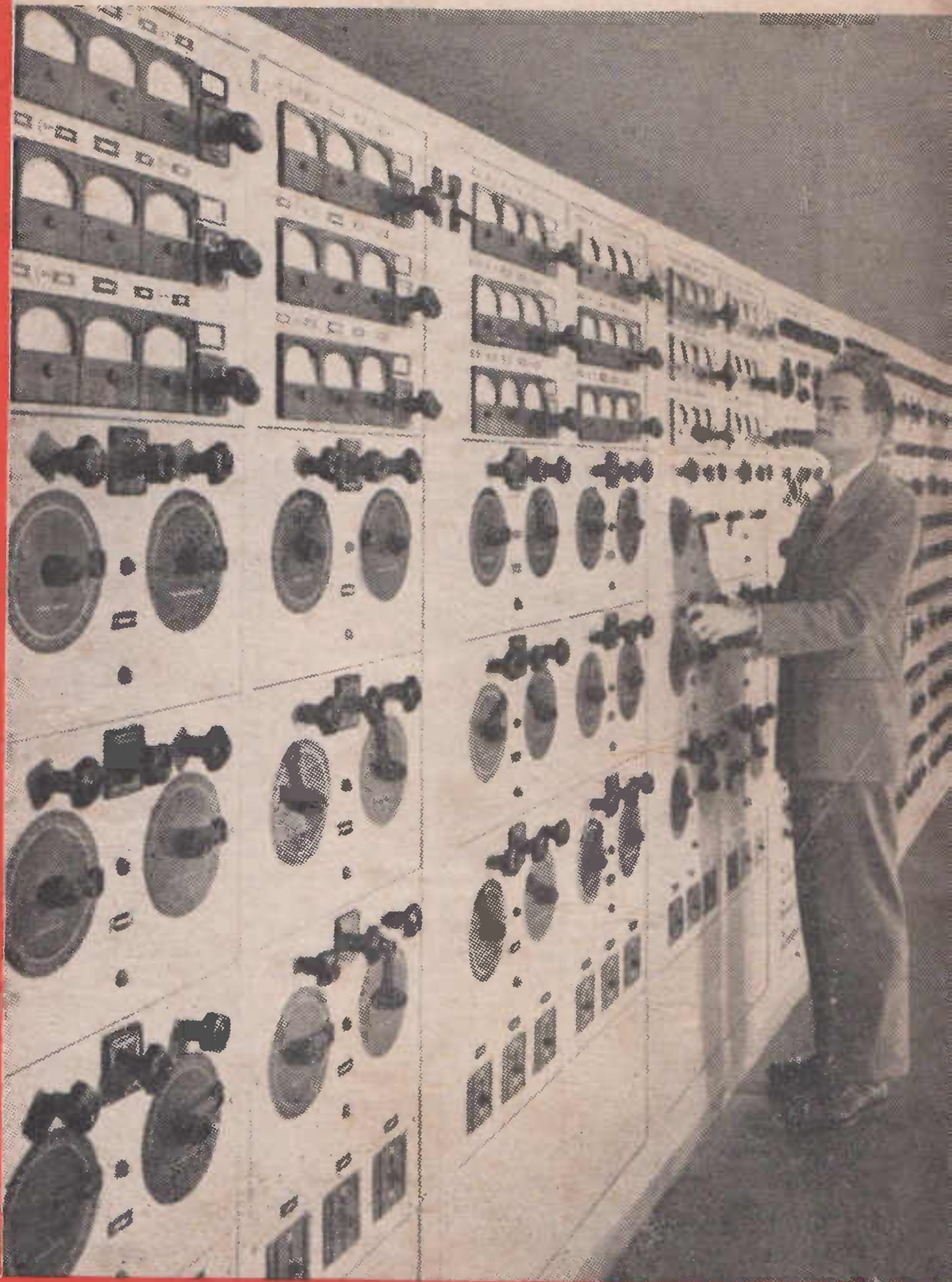

RADIO — ELECTRONICS — F.M. — TELEVISION

editorial.

F-M — Means Finer Musical Reproduction

Much criticism has been levelled at the FM method of broadcasting, the most recent being a statement in the daily press to the effect that, with rapid progress now being made in the Television field, FM has been outmoded and consequently likely to be discarded. It is hard to reconcile such announcements with the true facts, and they are not only erroneous and misleading, but simply serve to confuse both the radio trade and the general public.

Excellent and satisfactory results with the FM system of transmission have been obtained overseas, notably in America, which now has FM broadcasting stations from coast to coast. In addition, Canada, England, and certain Scandinavian countries are preparing to introduce this system. However, in this country, since the opening of the FM experimental stations, there has been too much criticism and little or no clarification of the true concepts of this much improved form of broadcasting, much to the detriment of the listening public.

As history shows, a radical change in any section of an industry has always met with much opposition both from engineers and the misinformed public, and because of these "it can't be improved on" addicts, benefits have been frequently withheld for many years from the public. In the case of FM, it appears to be the same story, and the critics of FM are apparently those who either unwittingly or purposely lack sufficient vision to appreciate the advantages which such a change in broadcasting transmissions could give to the people as a whole.

Many adherents to the AM system of broadcasting frequently quote the fact: "Why bother about FM when the listening public is not interested in high fidelity broadcasting?" To support this contention, they avidly point to the general practice of setting the tone control on the average receiver in the bass position, thus eliminating the high note response. Once again such statements simply indicate a lack of appreciation necessitating this reduction of "highs" by the listener.

The main reason for the listener preferring a bass response is, in general, due to the limited tonal range of their present AM receiver. A wide frequency range enables the various overtones of an instrument to be reproduced, thus making possible the easier recognition and, in effect, a more realistic appraisal of the instrument being transmitted—providing no distortion is present.

However, in the case of our present receivers which are limited to a high frequency response of some 5000 cycles, it is impossible to maintain the true tonal quality of the instruments, and in place of a true high note response all that is normally heard is a distortion of these higher frequencies. With such imperfect reproduction, relief from the consequent high note "screech" is most easily achieved by turning the tone control to the bass position. Although this naturally results in a somewhat "thin" tonal response, it is certainly preferable to enduring the distressful distortion.

With the true FM receiver and not compromise units likely to be foisted upon the unsuspecting public, such defects as mentioned above are not apparent. The FM transmitter is designed to give a frequency response of 50 to 15,000 cycles per second, and when manufacturers are in a position to provide receivers and components to handle this frequency range, then the listening public will have true fidelity.

Such facilities will extend the public's listening opportunities into the realms of fine music and should do much to educate those, who have trained their ears to accept the defective fidelity and inherent distortion of present-day transmissions, to enjoy more fully the benefits of such wide range reproduction.

RADIO SCIENCE

For the Advancement of Radio and Electronic Knowledge

Vol. 2 No. 3 MARCH, 1949

EDITORIAL CONTENTS

OUR COVER:—This much enlarged and greatly improved calculating board enables the rapid solution of complicated power system problems. The board can simulate up to 18 power sources and can be electrically divided in any desired manner for the simultaneous solution of two small problems, or can be operated as a single unit for a large-system study. Instrument scales read directly in power system quantities instead of requiring the use of multipliers, thus simplifying the work.

(Photo courtesy of Westinghouse Ltd.)

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COMPUTER—*Mathematical Merlin*

Fig. 1. The Westinghouse "Anacom" electronic analogue computer. The rotating synchronous switch is used to repeat transients, to build special forcing functions, and for other analytic purposes.

Rivalling the performance of Merlin, King Arthur's magician, the modern computer performs mathematical miracles in much less time than the twinkling of an eye. By doing so, computers, now in several forms, are providing answers to hitherto insoluble problems, enlarging the engineer's and scientist's knowledge of power.

This is an age in which century-old dreams of mathematicians are rapidly materialising. Until but a few years ago, only the simplest mathematical operations could be performed by mechanical computing facilities. But recent advances have increased man's computing ability far beyond proportion to the time involved.

The impetus for the development of large computers has come from many sources—the government, the military, and from scientific and industrial organisations. Each machine is best suited for one particular field. Yet, since mathematical principles remain unchanged, each machine is useful in other fields as well. Consequently, the more recent computers are designed for general purpose computations, although each is particularly adapted to certain fields.

Principles of Computers

A computer is a device that performs one or more mathematical operations. Data is supplied to the machine, which provides the answer. The computer may add, subtract, multiply, divide and take powers and square roots. It may integrate and differentiate. It may remember numbers and signs, refer to tables, interpolate and produce functions of dependent or independent variables. It may discriminate relative magnitude of quantities, whether they are increasing or decreasing, etc.

By

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Types of Computers

Computers can be classified into two types, the *digital* and the *continuous* (or *analog*). Digital computers operate only with whole discrete digits. Mathematical operations are performed by counting pulses on a counting wheel, electrical relays, or electronic tubes.

The basic principles of digital computers are utilised in the smallest types. The hand is a digital computer (digit means finger). It serves as a memory unit and an adding machine. It "*remembers*" numbers from zero to five, by the number of fingers raised. If the thumb is counted as five units and the other fingers as one each, the hand can remember numbers from zero to nine.

The *abacus*, also a digital computer, is an improvement on the hand as it remembers as many significant figures as there are strings of beads. On the Chinese abacus each string has two five's and five one's. Addition is much the same as with the hand, except that digits are added in any decimal place and the process of *"carry"* is introduced.

The carry operation consists of adding one in the next higher place to account for ten in the lower. Multiplication requires adding a number to itself the required number of times; division is the reverse, a repeated process of subtraction.

The first mechanical calculating machine, a digital unit, was built by Pascal in the 17th century. Modern office machines, like their prototype, are digital computers. They are based on the counting wheel with ten positions corresponding to the ten digits from zero to nine. Digits can be added in any decimal place. When one wheel passes its tenth position, the wheels automatically carry by turning the next higher wheel one notch, as in the automobile mileage counter. Large complex digital calculators operate in similar fashion.

Analog Computer

The analog or continuous computer, Fig. 1, compares the performance of one physical system with that of another having the same differential equations, which is a prerequisite for analogous systems although certain legitimate transformations can be made. Measurements are made on one physical system (known as the analog) to determine the behaviour of the other system in which the problem exists. In general, the systems are entirely different; for example, the electrical analog of mechanical equipment.

Analog computers are of the continuous type, as distinct from the digital. As the analog medium is continuous (rather than separated into distinct digits) numbers between digits are represented as readily as digits themselves. Analog computers usually indicate the answers on meters and instruments.

The slide rule, which multiplies or divides by adding or subtracting the logarithms of numbers, is an

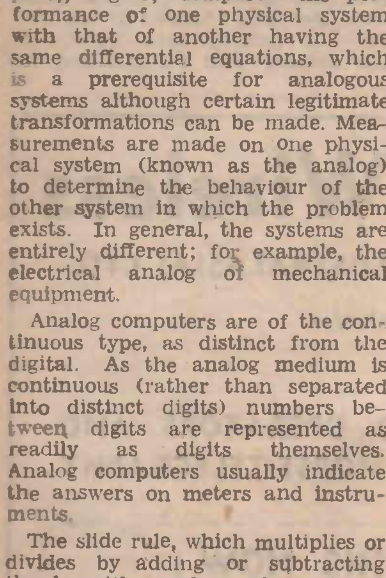


Fig. 2. The new Selective Sequence Electronic Calculator.

Fig. 8. The ENIAC is the highest speed computer. It weighs over 30 tons and contains nearly 18,000 valves.

analog computer. In this case, the numbers (or their logarithms) are not used as discrete digits, but are represented by analogous distances. Other analog computers use shaft rotations or currents and voltages as analogs of numbers.

The analog computer can be used to solve abstract differential equations. In such cases, the analog parameters and variables (distances, rotations, voltages, etc) are made analogous to corresponding terms and thus satisfy the equations.

Remembering and Handling Data

Remembering and handling data are functions vital to all types and sizes of computers, but particularly to larger machines. Without these functions computers would be very limited in calculating ability. Even the ordinary desk calculator has a *"memory."* The machine is based on a process of addition, which is repeated for multiplication.

In multiplication, the machine carriage is shifted so that the multiplier is added to itself the number of times called for by the value of each digit in the multiplier. Each position shift is equivalent to multiplication by 10, as in longhand multiplication. For example, in multiplying 4783 by 359, the machine first multiplies 4783 by 9, which equals 43,047. Then it shifts two places, multiplies by 3 (equivalent to 300) and again adds the partial results.

These operations require a finite period of time and hence the partial results must be remembered until added to obtain the final answer of 1,717,097. Therefore, the machine must have an *"inner"* memory for partial products of its own operations. Large business machines and computers likewise have an inner memory.

The desk calculator does not usually print or otherwise record partials, as they serve no purpose to the user. However, in many cases the machine must record the multiplicand, multiplier, and product. Some recording facilities print numbers on sheets, others punch holes in cards or tapes. These mechanical *"handling"* facilities may be as important as the purely arithmetic function because they save money, time and labor. Furthermore, mechanical handling makes it possible to record data permanently on cards and tapes (the *"outer"* memory).

Such data can be reused many times without rereading and resetting, thereby reducing the likelihood of error. Business computations require the storage in the outer memory of immense amounts of information concerning bills, salary accounts, taxes, inventories, etc. Similarly, large-scale computers store logarithms, simple and complex functions of angles, and similar data.

Digital Computers

Business Machines.

The types of digital computers vary from the simplest mechanical counting wheel to machines weighing many tons and containing thousands of vacuum tubes. The most common forms, however, are business machines, which include simple, hand-operated adding machines as well as units that approach large-scale calculators in complexity.

These machines are extensively used for making large numbers of business calculations. They have also been applied to complex problems of science, engineering, and warfare; for example, the calculation of missile trajectories. The solution of such problems requires a succession of operations, rather than only a single operation. Repetitive, multi-sequence processes are employed, in which successively closer approximations are reinserted by the machine into the formulas to obtain the next. This is continued until a final approximation, accurate within the desired limits is obtained.

The necessity of handling data manually between steps of such calculations limits the ability of desk computers and even business machines to solve more complex problems. This limitation has led to the development of large-scale computers in which this intermediate handling is also mechanised. The machines, directed before-hand as to what to do with intermediate

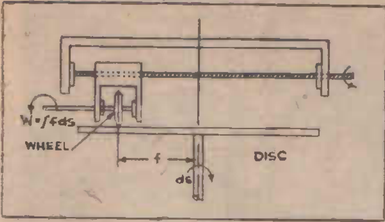


Fig. 4. The Integrator is the basic unit of the differential analyser.

results, proceed automatically until the final answer is obtained.

This function of mechanised intermediate handling has introduced new problems of planning ahead and coding into computers. But it also has improved immeasurably man's ability to calculate. Sequences of operations that would have required hundreds of man-years of desk-calculator or business-machine work are now accomplished in minutes. The limitation is no longer in the computing proper, but in preparing the data and coding the problem to go into the machine.

Large-scale Digital Calculators

While large-scale digital computers have in common the characteristic of operating with discrete digits, they differ as to speed, capacity and adaptability to certain problems. Punched cards or tapes and electrical connections are commonly used for inserting data and instructions and for extracting answers. These computers are employed principally on extremely complex problems requiring high accuracy and which can justify their high cost; for example, in calculating firing tables, trajectories of missiles, and astronomical data.

Early large-scale digital calculators employed the counting wheel as a basic unit. Later machines utilised the relay chain, which occupies more space but performs the same function at a much higher speed. Relay contacts are interlocked so that each new pulse picks up the next relay in the chain and drops the preceding one.

The chain is closed (returning from nine to zero) and the carry operation consists of advancing the *"ten"* chain one step when the tenh relay in he *"unit"* chain operates. This assumes a decimal (or base ten) mathematical number system. However, the base can be less than ten, which requires a smaller number of relays. A base of two (binary system) for example, is used in some computers.

The latest and highest speed computers employ electronic tubes in a manner similar to relays. Each pair of tubes (called a *"flip-flop"*) has two positions, *"on"* and *"off."* Only one *"flip-flop"* in a chain is *"on"* at one time. An incoming pulse energises the next *"flip-flop,"* which locks in, de-energising the preceding unit.

The arithmetic unit of a digital calculator, which performs the mathematical operations, contains the adders, multipliers, dividers, square rooters, etc., in the form of electronic tubes, relays, or wheels. The memory is usually divided into two parts; a high-speed inner memory and a slower speed outer. The high-speed memory, also tubes, relays, or wheels, stores and later transmits information obtained in intermediate steps and remembers instructions for later operations.

Memory Unit

In newer computers, the elements of this memory may consist of mercury delay lines, electrostatic digit-storing tubes (the Selectron), or magnetic drums, wires, or tapes.

The slow-speed outer memory consists of punched cards or tapes, on reels of magnetic wire or tape. It stores mathematical tables or functions or instructions that must be referred to less frequently during the calculation. The outer memory is almost unlimited in extent. However. the time required by the machine to look up data depends on the method used for selecting the

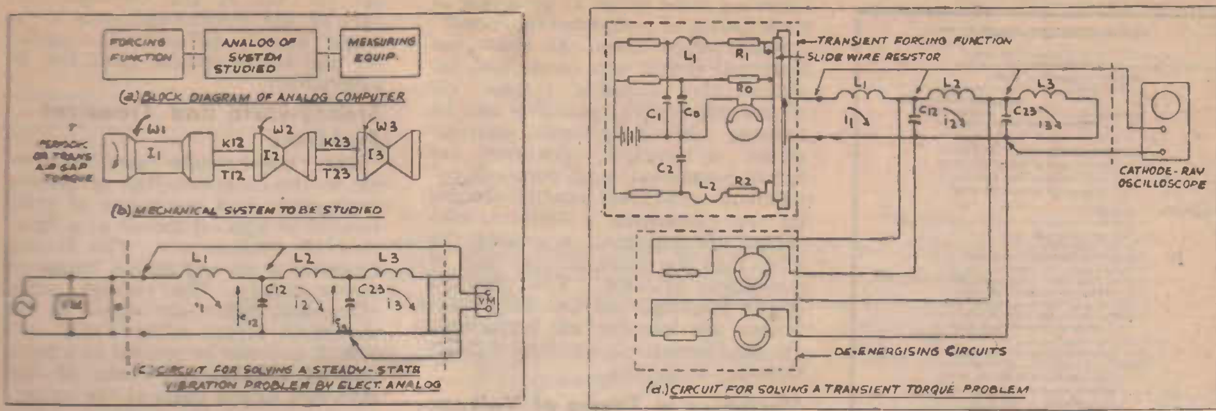


Fig. 5. Solution of a typical mechanical problem by electrical analog.

proper card or tape and finding the needed information.

The first large, general-purpose, digital calculator was built by International Business Machines Corporation, and was presented to Harvard University in 1944 for scientific studies. It is known as the IBM Automatic Sequence-Controlled Calculator. It had, until recently, the largest internal memory and most complete sequencing or programming facilities of any calculator. It was the fastest, but the electronic ENIAC, installed in 1946, has set an entirely new record in speed.

I.B.M. Calculator

Recently IBM placed in service at its headquarters in New York City the latest Selective Sequence Electronic Calculator, Fig. 2. This calculator combines extensive memory and elaborate programming facilities with the high speed attainable only with electronic arithmetic units. It can print numerical results at the enormous rate of 24,000 digits per minute or punch cards at 16,000 digits per minute for use in subsequent calculations. It has an inner memory in electron tubes, relays and tapes of over 4,000,000 digits, in addition to a practically limitless outer memory in the form of punched cards.

This IBM machine has a basic adding (or subtracting) time for 19-digit numbers of one thirty-five hundredth of a second. It multiplies two 14-digit numbers in a fifteenth of a second and divides them in a thirtieth.

Several relay-type digital computers have been built by the Bell System, and this machine can operate for long periods without continuous attendance. All information, data and instructions, is coded on punched tape similar to that used in teletype machines. The code is checked for errors by running two tapes punched independently by different operators through a comparing device. Other self-checking devices immediately stop the machine and signal personnel when an error is made.

The ENIAC

The ENIAC, Fig. 3, built by the University of Pennsylvania, the first large-scale electronic computer, weighs 30 tons and contains nearly 18,000 electronic tubes. It has the amazingly high speed of 5000 ten-digit additions or 360 ten-digit multiplications per second. The high-speed memory can store 20 ten-digit numbers, sufficient for the missile-trajectory problems (the principal objective in its design) but insufficient for general-purpose computing.

In addition, it has three tables, each of which can store up to 104 twelve-digit numbers before computation starts, for setting up arbitrary functions. These numbers can be referred to in one thousandth of a second. The ENIAC can calculate the trajectory of a shell in less time than the shell requires to reach its target. But several new digital calculators will be substantially faster than the ENIAC.

Analog Computers

The Differential Analyser.

The differential analyser, first placed in service in 1930, is an analog-type calculator for solving integro-differential equations. It uses shaft rotations as analogs of numbers and integrates in the manner of a planimeter. The computer is an assemblage of integrators, shafts, gears, plotting tables, and equipment for connections and control.

The differential analyser makes use of the fact that a differential equation can be reduced to an integral equation. Hence the machine need only integrate.

The basic unit is the integrator Fig. 4, which consists of a disc and wheel. To integrate a WORK problem, for example, the radius at which the wheel runs on the disc is equivalent to force (f), and the disc rotation to ds (derivative of distance) Thus wheel rotation equals the *work* of fds. The integrator is made practically frictionless by a polarised-light servomechanism linking the wheel to a driven member. Addition or subtraction of rotations by differential gears, is equivalent to adding or subtracting integrals and variables.

The differential analyser has been improved considerably in recent years. Early machines were set up manually by changing plotting tables, integrators and gears. However, in 1942, Massachusetts Institute of Technology placed in service a completely redesigned and expanded version, in which set-up time has been greatly reduced by arranging the elements as separate units connected electrically through servomechanisms. Differential analysers have been used on problems involving ballistics, voltage regulators, servomechanisms, non-linear electrical and mechanical systems, and others.

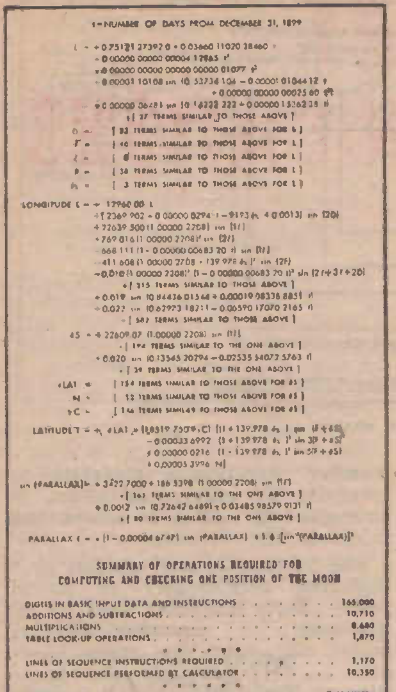
Network Calculators

One of the first large-scale analog computers, the d-c network calculator, was developed about thirty years ago. Its purpose was to reduce the time, labor and engineering skill required to solve problems of electric-power networks. Without the board, such problems would be solved "manually." If a network contained fifty loops, which is not uncommon, fifty simultaneous equations would be solved—by no means a small task. Using the calculating board, the problem is set up in miniature with line resistances, generators, and loads represented by analogous components. The answers, current flow and voltage at different points in the network, are read on built-in instruments.

The d-c board was limited to in-phase problems or those that could be approximated as such. To circumvent this limitation, the a-c board (see front cover) on which phase angles as well as magnitudes are represented, was built in 1929. The electric power industry now has about 18 such computers.

Electrical-Analog Computers

In addition to solving network problems, the a-c network calcula-



This diagram shows the different equations and computational operations which have to be carried out by an electronic calculator in solving a typical complex scientific problem. This particular illustration represents the calculations necessary to determine a single position of the moon for astronomical purposes. It can be completed by the IBM machine in seven minutes.

tor is used in solving mechanical problems; for example, to determine resonant frequencies and steady-state torque amplifications in multi-mass systems. Also, its circuits are used in the electrical-transients analyzer, together with oscillographic recording equipment for the computation of electrical transients and synchronous switching equipment for studying complex phenomena by a repetitive technique.

Since the completion of the a-c board, the electrical-analog method has been increasingly applied to the solution of problems in many varied fields such as hydraulics and applied mechanics. Much heat-flow work has been done by Columbia University and others. The mechanical-transients analyzer extended the transient computing technique to mechanical systems. A servo-analyzer employing amplifiers and time-delay circuits, is employed to study regulating systems and servomechanisms.

"Anacom" Computer

In 1946, Westinghouse and the California Institute of Technology jointly embarked on the development of two large-scale general-purpose electrical-analog computers of substantially identical components. The Westinghouse unit is known as the *Anacom*. These computers can handle a wide range of problems in electrical- and mechanical-engineering and allied fields. An analogous electrical circuit can be devised for almost any physical system for which differential equations can be written. Linear systems (systems whose differential equations are linear expressions with constant coefficient) are most readily studied by the computers. However, elements are provided to extend the units into the more general field of non-linear systems. The elements of the Westinghouse-Cal Tech computers are capable of performing all the operations involved in differential equations.

Variables in Terms of Voltage and Currents

The computers represent variables in terms of voltages or currents. Variables can be added or subtracted by connecting equivalent voltages in series. A variable can be integrated or differentiated by passing an analogous current through a capacitance or inductance respectively (since $e_C = I/C \int i\,dt$ and $e_L = L\,di/dt$). The result is equivalent to the voltage across the corresponding circuit element. Multiplication or division of variables is accomplished by a multiplier, an electronic circuit. Arbitrary functions (functions of any shape) of dependent and independent variables are provided by the computers for simulating complicated variables. Time scale and power level can be changed to suit the best range of operation of the circuit elements provided. Measurements are related by known multipliers to corresponding quantities in the actual system.

The block-diagram of the computer, Fig. 5 (a), for solving any problem consists of three elements. First is the forcing function, which generates electrical voltages equivalent to the forces applied to the actual physical system. Second is the electrical analog of the system being studied; many analogs of different problems are already known and methods are developed for systematically determining new ones. Last is the measuring equipment which usually includes oscillographic apparatus for transient problems. The exact type of measuring equipment may vary with each individual analysis.

Application of the electric-analog computer in solving two typical mechanical problems of a three-mass rotating system is illustrated in Fig. 5 (b), (c) and (d). One is a steady-state vibration problem and the other a transient-torque problem. The analog of the system consists of three inductances proportional to the three masses and two capacitances proportional to the reciprocals of the shaft spring constants. To obtain the correct overall analog, the equation of each analog element is simply made identical to that of the corresponding part of the mechanical system. A single overall differential equation for the entire system need not be determined.

Steady-state and Transient Problems

The steady-state problem requires the determination of natural frequencies and the ratios of shaft torques to applied torque as a function of frequency. The forcing function is an adjustable frequency power supply. The voltage ratios, e_{12}/e and e_{23}/e are equal to the analogous torque ratios T_{12}/T, and T_{23}/T, and can be plotted as a function of frequency. Peaks of current and torque come at the natural frequencies of the systems, which are identical.

Transient problems, such as indicated in Fig. 5 (d), must be solved to design turbine-generator shafts and couplings to withstand the torques imposed upon them during short circuits. The forcing function required is complex but it can be simulated accurately by the electrical components of the computer. The forcing function contains three terms generated separately by three resistance - inductance - capacitance circuits. These circuits are initially charged and are discharged simultaneously through a slide-wire resistor producing a voltage drop, e, analogous to the actual torque applied during a short circuit. When this voltage is applied to the analog circuit, the oscillograph reads the applied torque, T, the generator-shaft torque T_{12}, or the turbine-shaft torque, T_{23}. The phenomenon is repeated ten times per second by means of a synchronous switch; the time scale is made to suit this frequency. De-energising circuits restore a condition of rest during the "off" periods between transients. The result is a continuous record on the oscillograph, which is observed or photographed and then analysed to determine the effect of short-circuit torques on the mechanical system.

This problem is simply illustrative. Others are solved in similar fashion. Different forcing functions, analog elements, and measuring devices are provided in the computer, making it suitable to all types of problems.

Main Advantages

The advantages of the electrical-analog computer lie in its flexibility, which makes it adaptable to a wide variety of engineering problems involved in the design of equipment and systems in many fields. It is suitable only where the usual engineering accuracy is sufficient. In general, the accuracy is limited by the initial data, rather than by the computer, and the answers are as accurate as can be justified.

The rapid development of both digital and analog computers is no-

(Continued on page 46)

PROBLEMS OF MILITARY RADIO COMMUNICATIONS

The success of military operations in the future will depend on a communication system of adequate mobility, traffic capacity and reliability. This article discusses a number of limitations of existing techniques, as well as analysing the factors which prohibit the realisation of such a system at the present time.

The success of military operations in the future will depend greatly upon the availability of a communication system of adequate mobility, traffic capacity and reliability. An analysis of the factors which prohibit the realisation of such a system at the present time shows the need for research in all phases of radio communication. A number of the more pressing limitations of existing techniques are discussed to develop the basic research problems.

An examination of military history shows that in each new war there are improvements in offensive tactics which may take either of two forms, increase in fire power or increase in mobility, or both.

History also teaches that the effective use of each new weapon and defence against it requires communications improved in speed, volume, and reliability proportionally greater than the increase in speed and power of the weapons.

Future Operations

No one can now foresee what military operations of the future may be, except that there will be atomic power instead of TNT, and rockets instead of aircraft. Defence as well as attack will depend upon the strategic deployment of small, fast-moving, hard-hitting forces transported and supplied by air for long periods. These units will require the closest of co-operation and co-ordination of all arms and services.

In many respects, future operations may resemble those of the last war in the Pacific more than those in Europe. There will probably be many small theatres of operation each of which must have communication with the others, and with the staff and supply organisations of the United States. In addition to the command and administrative traffic of the past, these circuits must carry other forms of electrical signals representing, for instance, facsimile, map co-ordinates, meteorological conditions, and others, for, with long-range missiles, one of the principal functions of these outposts will be defence of the Zone of the Interior.

The military services face the task of devising a system of communication capable of carrying all the types of traffic required by push-button warfare in volume far greater than anything previously experienced with reliability comparable to the best commercial telephone and telegraph practice, and capable of being installed in any part of the world, inhabited or not, in any climate, in the shortest possible time. This means, of course, that the equipment must be air-transportable with the consequent drastic limitations on size, weight, and personnel. Regardless of advances in science, there have been practically no improvements in mankind, and so this system must be usable by troops not very different in capability from those who manned the first crossbow infantry.

by
JOHN HESSEL
(S.M., I.R.E.)

To provide the required speed and mobility, it is evident that there will be much greater reliance on radio in the future and, therefore, that the traffic capacity and reliability of radio communication must be greatly improved. Despite the advances made in the last war period, and the wide dispersion of our forces, wire lines still carried approximately 95 per cent. of all message traffic. Wire lines must still be used, wherever they are available in the future, as the backbone of the communication system, leaving the radio-frequency spectrum free for those services which wire lines cannot provide.

Long-Haul Circuits

Radio communication is used for three primary functions. First, it provides communication over long-haul circuits where no wire facilities exist or are practical. An example of this type of circuit is the Army Command and Administrative Network which links the Department of the Army with its outposts over the world. The introduction of the carrier-shift radioteletype greatly increased the traffic capacity of these circuits during the war years, and made it possible to route teletype on a subscriber-to-subscriber basis without the immense waste of time and effort in message and signal centres at either end of the radio circuit.

Some Basic Difficulties

But several basic difficulties remain. The usable frequency spectrum for long-range sky-wave transmission lies between about 3 and 30 Mc and cannot be expanded. High-frequency assignments are not private trunk circuits but party lines, subject not only to interference from the enemy, and from enemy sources beyond control, but also from natural static and vagaries of the ionosphere. There are not enough usable frequency assignments in this spectrum to meet all requirements in time of war by present methods.

The fundamental problem is to develop the means for making the best possible use of every cycle of the spectrum. If it were practical to use single-sideband transmissions exclusively, the possible number of available voice channels would be doubled. But, before this can be done, single-sideband transmitters must be simplified to the point where they can be operated by armed forces personnel — not engineers. Present day carrier - shift teletype circuits require frequency assignments with about 5000 cps separation. On wire lines the standard bandwidth of teletype channels is 170 cps. When radio can do as well, the number of available teletype channels will be increased by a factor of 30.

One method, of course, is to multiplex the teletype signals on a frequency-division basis, and modulate the transmitter with the resultant on a single-sideband basis. By this means, it may be possible to get about sixteen circuits in a 5-kc transmitter band, an efficiency compared with wire circuits of about 80 per cent.

This has not been done yet, but is conceivable in the not-too-distant future; however, there are many requirements for single-channel radioteletype circuits, and methods are required by which it is possible to assign channels for such service with a separation of only a few hundred cycles, rather than 5 kc as at present. The fundamental fact is that there is not enough now known about circuitry, or about the fundamental chemical substances of which circuits are composed.

Still, one must reckon with the vagaries of the transmission medium, including the ever-varying ionosphere. Space-diversity reception can be used at fixed installations and when installation time is not critical, but mobile terminals are also required where space diversity is impossible. Frequency diversity is possible, of course, but this means that bandwidth is sacrificed. Double-frequency transmission loses all that has been gained by single-sidebands transmission. There is need for the development of a method of diversity reception usable on mobile terminals, and which does not cost bandwith.

Circuits To Moving Terminals

The second primary use of radio communication in the Army is to provide circuits to moving terminals where wire circuits cannot be installed. Examples of such circuits are the radio networks in armored forces and in air forces. Prior to the war, it was found advantageous to use frequencies above 20 Mc for this service. This freed sky-wave frequencies for use in long-haul circuits and, conversely, eliminated long-range interference with short-range circuits.

The advent of FM practically eliminated all other interference, and permitted the operation of short-range tactical radio networks of quality and reliability comparable to telephone loops. Because of the limited interference range of such transmissions and capture effect, frequency assignments can be duplicated at rather short range; hence, thousands of such networks can be operated within a theatre area. But the demands for such service again far exceed the available assignment within the interference range.

With present techniques using crystal-controlled oscillators in both receiver and transmitter, a 3000 cps voice band is transmitted with a 5 to 1 deviation ratio occupying an rf bandwidth of 30,000 cps. But still it is necessary to separate frequency assignments by 100 kc because of instabilities and inadequate selectivity. Thus, two out of three possible assignments have been wasted not counting those lost due to interference at short range, even with this separation.

Problem of Crystals

By the use of the most stable crystal-controlled oscillators and filters, it is possible that the channel separation can be cut to 50 kc a saving of two to one. But the problem of producing crystals of this quality in quantities something like twenty times greater than were produced in the last war per unit of troops is formidable. The problem, then, is to develop oscillators and circuits of stability as good as modern quartz crystals, but without the crystals, and preferably tunable.

In this case, it is interesting to note the part which quartz plays in stable design. The best dielectric material for variable capacitors and for coil forms is fused quartz. To minimise the temperature effect caused by metals in variable capacitors, it is necessary to make the whole structure of quartz and to provide conductivity, where required, by plating. For stability in the microwave region, quartz is used for resonant cavities. The problem is to develop materials, both conducting and dielectric, having the stability of quartz without its manufacturing difficulties and its fragility. This is a problem for the chemists and physicists.

Radio Relay Systems

The third primary use of radio communications is for radio relay systems. This use grew out of the preceding two, in an attempt to provide long-distance circuits of good telephone quality without expending the precious high - frequency spectrum or being subject to its interference. The first attempts were simply forward echelon very-high-frequency FM sets with the transmitters and receivers back-to-back at relay points. Later, pulse modulation of centimeter waves was introduced by adaptation of radar techniques. The frequency-modulation sets handled four voice channels, frequency-division multiplexed, while the centimetre-wave sets handled eight channels by time-division multiplex. Basically, radio relay provides an r-f substitute for wire and cable long-distance trunk circuits. The advantage is that it costs much less shipping tons per circuit mile, and can be installed more quickly with less men.

The demand for this type of service is complete evidence of its value. But important as this new achievement now is, a comparison with telephone circuits indicates its present faults. The FM radio relay of World War II handled four telephone circuits over not more than five or six jumps of about thirty miles each, with a signal-to-noise plus crosstalk ratio of something like 20 db. A standard Bell System K carrier circuit handled twelve channels per cable pair over the same distance, with approximately 50 db signal-to-noise plus crosstalk ratio.

The centimetre wave equipments were designed to perform as via trunks with 50 db signal-to-noise ratio. But they are limited to eight single voice channels, one of which is usually used as an order wire for maintenance purposes. There is no provision for transmission of wide-band signals, such as television or high-speed facsimile. On the other hand, coaxial telephone cables now handle frequency-stacked groups of 480 voice channels or television signals out to 4 Mc. It is necessary to provide very-high frequency FM radio relay comparable in performance with commercial carrier telephone service, and microwave radio relay circuits comparable with coaxial to telephone cable.

Mathematical Analysis

Careful mathematical analyses have been made of all the aspects of this problem. These show that the most difficult problem to be solved is to devise a distortion-free means of modulating wide-band signals upon a microwave carrier and subsequently demodulating them. To handle a multiplexed group of 100 voice channels in a bandwidth of 500 kc, and to transmit them over 100 jumps averaging 30 miles and recover each with a signal-to-noise and crosstalk ratio of 50 db, requires that the distortion caused in each link be less than 0.1 per cent.

Antennas

There are, of course, many other problems of a general nature which remain to be solved. One of these is the insistent demand for more efficient and more effective antennas. With the use of wider and wider frequency coverage, there is insistence upon the development of broadband antennas which need not be tuned and for smaller antennas (for instance on tanks) which are not so visible and do not interfere with the guns. The infantryman demands an antenna which does not interference with his progress in the jungle and make him the prime target of every sniper who knows what an antenna means. It is necessary to plan for major installations to be in deep bombproof shelters, and it may be unsafe even to make tuning adjustments on the surface, to say nothing of repairing bomb damage.

The terms "efficient" and "effective", used to describe the performance characteristics, may be differentiated in this way. A transmitting antenna is efficient if it radiates practically all of the energy available in the output circuit of a transmitter. A receiving antenna is efficient if it delivers substantially all of the energy which it collects at the receiver input teminals. Generally speaking, both transmitting and receiving antennas may be made efficient, if they operate near their reasonant frequencies and are properly matched to the input and output circuits. This would seem to dictate that, for small, inconspicuous antennas, an extremely high frequency must be used. But the amount of energy which a receiving antenna collects is a function of its physical size, other factors being equal.

Effect of Frequency

Therefore, as frequency is increased and the size of a resonant antenna decreased, its effectiveness as a collector goes down, although its efficiency may be constant. In cases where a resonant antenna cannot be used, coupling circuits must be provided which cancel the reactive component, in addition to matching impedances. With these, good efficiencies can be achieved if the network is substantially loss-free. Theoretically, this technique could be carried to the point of efficiency radiating energy from antennas which are extremely short both physically and electrically. But the technique has yet to be devised whereby large amount of energy can be collected with a receiving antenna which is physically short. What seems to be needed is an effective wave magnet.

The present understanding of the behavior of antennas is based on the work of Maxwell performed about eighty years ago. Since that time, his work has been studied repeatedly without discovering phenomena which cannot be explained by his equations. They are, therefore, considered valid and are accepted as a law of nature. If it is true that present-day antenna designs represent nearly the ultimate which can be achieved by these theories, then the radical improvements which are needed can be achieved only after fundamental discoveries as basic and as advanced as Maxwell's have been made.

Planning Future Research

Planning the research and development programme for the solution of problems such as these is one of the foremost jobs in which the service laboratories have been engaged since the end of hostilities. The Signal Corps alone is sponsoring research and development totalling millions of dollars in scores of universities and colleges and private and commercial laboratories, in addition to its own efforts.

(Continued on page 46)

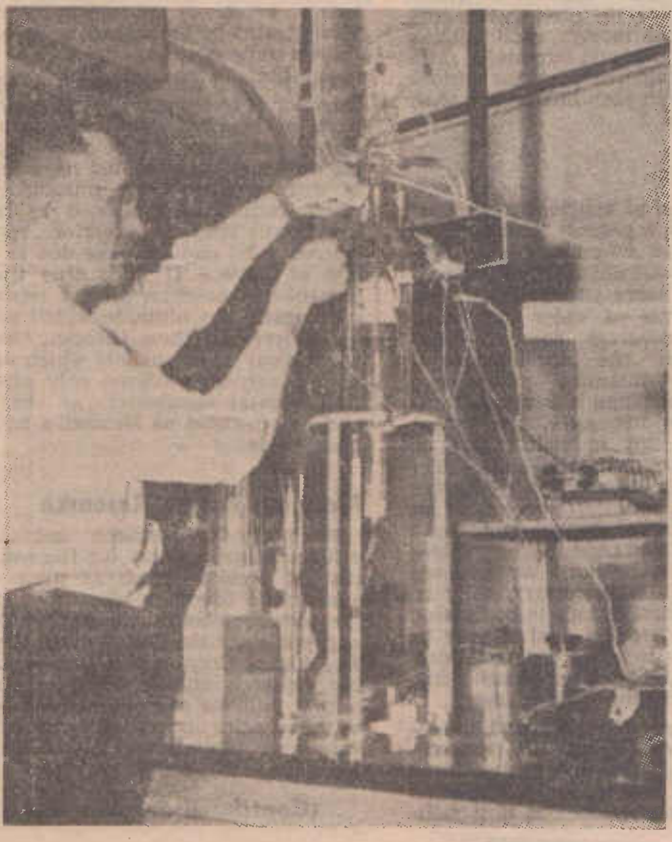
A Technical Survey of Latest Overseas Developments

R-F MASS SPECTROMETER

A recently developed mass spectrometer tube by the National Bureau of Standards provides a means of exploring the little known fundamentals of negative atomic ions and a simple method for studying positive ions.

Development of the new tube was brought about by attempts to investigate conditions leading to the formation of negative atomic ions of the heavier elements. These negative ions, consisting of atoms with extra electrons, have very low energies of formation; and their study has been difficult because of their rapid dissociation in the very short distances before they reach a measuring electrode.

Since their discovery about 40 years ago, negative ions have been detected for only a few elements although theory indicates that many elements should have such ions. Previous experiments indicated that negative ions might exist in many familiar forms of electronic tubes, but that they would not be detected if the discharge path within the tube was longer than an inch.



Dr. W. H. Bennett, of the National Bureau of Standards, adjusts the new and simplifed flexible radio-frequency mass spectrometer.

It was necessary therefore, to devise an experimental method for separating and identifying such ions within distances of only a few centimetres. This was accomplished through the new mass spectrometer tube.

Advanced Form

In its more advanced form, this two stage spectrometer may be used for positive ions as well as negative ions. Essentially the equipment consists of a multigrid tube in which an adjustable radio frequency is applied to two grids while all other electrodes are held at proper d-c potentials and the ion current is measured at the plate.

The more exacting requirements of negative-ion separation require the use of a small negative field produced with coils, but if positive ions are being separated no magnetic field is needed. Because large electromagnets or tubes containing electrodes with elaborate split systems are not required in this method, the radio-frequency mass spectrometer should find wide application where its resolution is sufficient.

One of the principal limitations upon the resolution possible with the ordinary mass spectrometers using magnetic deflection of beams has been spread in energies at the ion source. The percentage spread occasioned by this factor can be reduced by increasing the voltage applied to the ions before they are magnetically resolved. The extent to which this can be done is limited, however, by the magnetic field that can be obtained in a space sufficient to contain the tube.

Resolution Improved

In the radio-frequency mass spectrometer this difficulty is eliminated and the voltage on the ions can be easily pushed up at least an additional order of magnitude to any value for which insulation can be provided. The frequencies are then increased by an amount equal to the square root of the factor by which the voltage is increased. Raising the voltage from 100 to 10,000 volts, for example increases the frequencies tenfold and reduces the percentage spread of mass line due to velocity spread in the ion sources by a factor of one-hundredth.

Operation of Spectrometer

The radio frequency mass spectrometer tube consists of a cathode near which positive or negative ions are formed, several grids and a plate. If negative ions are to be studied, a small magnetic field is required to confine the electrons to the space inside the first grid to prevent formation of positive ions in other parts of the tube.

Ions arising at the cathode are accelerated through the first grid into the alternating field of the second grid, to which the r-f voltage is applied. Those ions that enter this field at the proper phase, and which have a mass and velocity related to the frequency of the field, pass through the second grid as the r-f potential changes polarity. Thus these ions are accelerated while travelling from the first to the third grid.

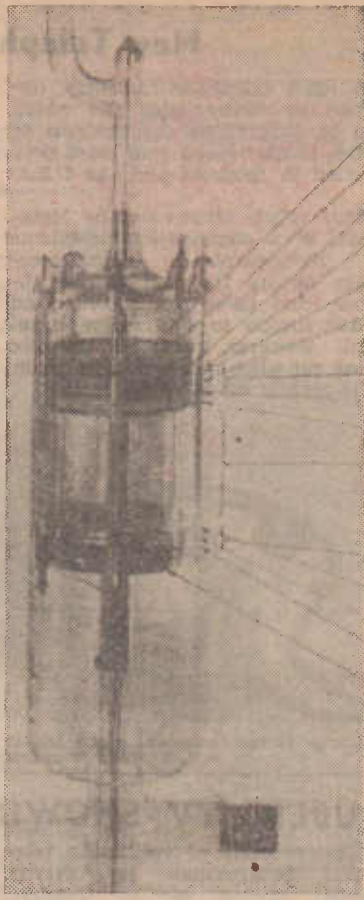
A blocking potential, nearly equal to the maximum energy with which ions of the proper mass emerge from the r-f field, is applied to the fourth grid and the current to the plate is observed, thus indicating the rate at which ions of a particular type are being formed.

Cascaded Units

The method can be extended to two cascaded units to obtain a high order of mass resolution. In its more advanced form, the double-stage spectrometer can be used for measuring positive or negative ions. The equipment consists essentially of a multigrid tube in which the adjustable radio frequency is applied to two grids, one in each of the two stages, while all the other electrodes are held at appropriate direct potentials. As in the single stage unit, the ion current is measured at the plate. The exacting requirements of negative ion separation require the use of a small magnetic field produced with external coils, but no magnetic field is required if positive ions are being separated.

Many Possible Uses

The simplicity and low cost of the radio-frequency mass spectrometer should make it attractive not only in those applications in which its special characteristics makes it superior to any other kind of mass spectrometer, but also in those laboratories where the expense of other equipment is prohibitive. Though the possibilities of the new apparatus have not yet been adequately explored, preliminary experiments indicate that many specialised uses for this kind of tube will come to light as it becomes better known.



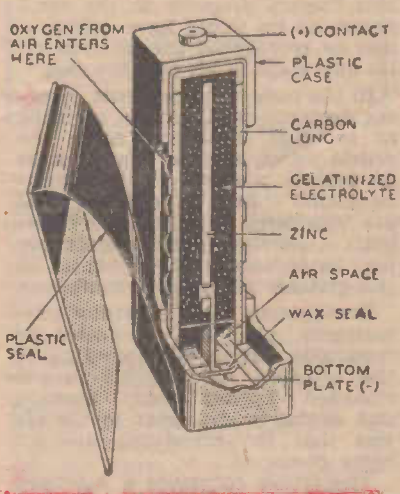
A view of the new r-f mass spectrometer tube.

LONG LIFE DRY BATTERY

A dry battery developed by the National Carbon Co. for use in hearing aids is claimed to have a service life three times as long as a standard cell. Although this new cell requires oxygen to neutralise the hydrogen which would otherwise collect on its carbon electrode, it does not use the usual oxygen liberating manganese dioxide.

Instead it draws its oxygen supply from the air, and as a result the large space usually taken up by this manganese dioxide is now used to hold a larger supply of active chemicals. What allows the battery to draw its oxygen from the air is its peculiar "inside out" construction. Most flashlight cells have a zinc casing with a carbon rod up the middle, whereas in this new design a zinc core is placed between two plates of porous carbon. The carbon plates are placed against openings in the sides of the case. In manufacture a strip of adhesive tape covers the windows, and before use this is peeled off. The sketch shows these main details.

—Courtesy Radio Electronics.



FM Receiver In Buses

A new FM receiver designed specifically for installation in buses will operate up to eight speakers enabling low level operation of each one. The set, designed for fixed tuning, is crystal tuned to the frequency of any one FM station desired.

Employing 10 valves, the receiver has double limiters for optimum quieting of man-made static and other interferences. The crystal employed in controlling the local oscillator is a new design, operating on the third mechanical mode and requiring a frequency multiplication of only three. This enables circuit simplification and easy alignment. The set incorporates a crystal controlled local oscillator, and a vibrator power pack which boosts the 12 volts from the bus battery up to the higher voltages necessary for operation.

Standard 6½ inch speakers are used, the number required depending on the size of the bus, and once installed the volume of the receiver cannot be changed by either the driver or passenger in the bus. Tests to date have shown reception to be satisfactory with the bus operating up to 20 miles from the transmitter.

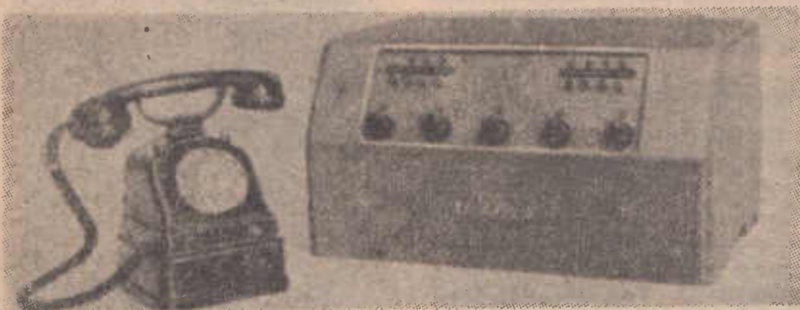
New Telephone Recorder

A robot telephone secretary, designed in Switzerland, and which can be adapted to any business or home, is now going into mass production in England and the U.S.A.

This robot, known as the *Notaphon*, is a combination telephone and phonograph for taking messages during the subscriber's absence, and these are recorded on a disc similar to a phonograph record. However, instead of the disc being cut when a recording is made, it is merely magnetised.

The Notaphon can be connected to any standard telephone instrument without altering or interfering with the latter's mechanism. When a call comes through and the receiver is not removed after three rings, the Notaphon automatically goes into action.

It first announces the subscriber's name and address, and then requests the caller to speak. If he does not do so within eight seconds, the request is repeated; if he still does not speak, he hears "Notaphon ringing off."



A view of the Notaphon, which can be attached to an ordinary telephone to record any incoming messages during the owner's absence.

As soon as the caller utters a sound the recording mechanism starts to function. A silence of eight seconds automatically cuts it out. The whole arrangement is simple and foolproof.

One of the several novel features of the Notaphon is a vocal secret code, preset by the subscriber which enables him alone to playback the messages recorded on the disc. By dialling his own number from any telephone, waiting for the Notaphon's request to speak and then pronouncing the vowel sounds forming his secret code, he sets the reproduction mechanism into motion. Five thousand possible code variations ensure complete secrecy.

On completing the playback, the robot requests its master to erase the recording. This is done by pronouncing another predetermined vowel sound. Deletion is verbally confirmed by the Notaphon, which now regains its full half-hour capacity. If deletion is not desired, the recording of later calls on the disc starts where previous recording stopped. When the instrument's capacity is exhausted, the robot voice informs subsequent callers of the fact.

(Courtesy Radio Craft).

PUBLIC TV SHOWING MAY BE ILLEGAL

The practice of exhibiting television programmes in taverns, hotels, motion picture theatres, dance halls and other public places can be legally stopped. according to an article in the current issue of the Columbia Law Review. Author of the article entitled "Unauthorised Uses of Television Broadcasting" is D. M. Solinger, a New York attorney, and this is believed to be the first authoritative analysis of one of the major problems arising from the rapid growth of the television industry.

According to the Law Review article, typical of the problems that have developed in recent weeks are the following:

"May a tavern pick up a television programme for the entertainment of its customers without authorisation from those who originate the telecast? May a hotel furnish television to its guests in private rooms rented, perhaps at a premium, or in its public halls, without the consent of the telecaster? May a motion picture theatre entertain its patrons by making television programmes available, either on its regular motion picture screen or elsewhere in the theatre, without authority? May an unauthorised motion picture be made from a television performance; and may such motion picture be exhibited without the consent of the originator of the telecast?"

Examining the legal aspect of television broadcasting rights Mr. Solinger states that Television is protected by statutory and common law copyrights, as well as by other common law property rights.

"An owner of a television receiver," he writes, "by performing a programme in a tavern, hotel, restaurant, private auditorium, or motion picture theatre, has thereby infringed on the common law copyright of the creator of an original literary property in the same degree as he would have infringed had he reproduced the material on his own stage in his own live cast."

In the case of news events, clear-cut decisions will have to be made as to what constitutes news, the article states, because "there can be no private property right in news as such.'" Even if sports events are considered news, public exhibitions of televised sports programmes may be restrained by the courts on the grounds of unfair competition.

Broadcasters of television programmes are also protected by "equitable servitudes," according to the article. An example is the standard announcement opening and closing programmes, to the effect that the broadcasts are for home reception.

The article concludes a summary of legal devices available to prevent unauthorised use of television broadcasts and notes that similar results could be obtained by legislation. Existing legal tools should be sufficient, however to "resolve whatever conflicts of interest may arise."

—Courtesy Radio News.

Photovision

Photovision is proving increasingly startling as an economical, versatile and altogether practical means of transmitting both pictures and sound from one point to another over light beams in place of conventional radio waves or conducting cables.

The system operates in light or in darkness and quite without interference from static or other causes inherent in radio communications. It will transmit color pictures as well as black and white. Photovision not only simplifies the problem of transmitting television programmes in short range relays, such as from football field to main transmitter, but may be used in place of coaxial cable for inter-city relays.

Rats with Radio

To measure the effects of electrical brain stimulation rats wired for radio are now being used. A small radio receiver consisting of a miniature crystal rectifier, and wire electrodes are placed within the rat's head by an ingenious operation.

High frequency pulses generated in the laboratory are received, rectified and transmitted by an electrode to the proper part of the brain. The new method gives the rat freedom of movement for observation in contrast to an older method of direct wiring.

K. B. WARNER
Amateur Radio Pioneer

Kenneth Bryant Warner, the man who gave amateur radio to the world, is dead. More than a quarter million radio amateurs in over 200 countries are mourning his death.

As managing-secretary of the American Radio Relay League, editor of QST and the Radio Amateur's Handbook, K.B.W.—as he was known to the amateur fraternity—devoted his life to the great hobby and put it on the high level it stands today.

Although only known personally to a comparative handful of radio enthusiasts, he was revered by any man who ever sent a CQ. They all knew they owed their pleasure of radio communication to this pioneer whose tact, diplomacy, administration and general personality won him a world of friends.

For years he fought for amateur radio. For years he studied the electronic trends and brought them within the scope of the radio amateur through QST. For years he worked for the greatest ideal of the human race—the brotherhood of man. He saw in international amateur one way of achieving this long-sought goal.

Pacifist by Nature

He was by nature a pacifist but when he saw the democratic countries plunged into war in 1939 he was to the fore with the Defence Edition of the Radio Amateurs' Handbook—a standard text book used in most signal schools in the Allied services.

His chief ambition was a united front in amateur radio. He lived to see this ideal realised—first for America in the A.R.R.L. and second for the world in the International Amateur Radio Union—the world governing body of amateur radio. He was as well known abroad as in his own home town of West Hartford, Connecticut.

For more than two decades he represented his A.R.R.L. and the I.A.R.U. at international conferences. In Havana, Lisbon, Cairo, Copenhagen and last year in Atlantic City he carried the banner of amateur radio, fighting—sometimes losing but more often than not winning—for the great hobby against the nations keen on more high frequencies for the broadcasting of political propaganda.

The new 21 megacycle band, shortly to be used for amateur radio communication, was gained largely through K.B.W's research and sane reasoning at the Atlantic City Tele-communication conference last year.

A born administrator and journalist, his editorials in QST were read by thousands. His case was put simply and understood by schoolboys, university professors, business magnates, workmen and the thousands interested in amateur radio.

When Ross Hull, technical editor of QST, was electrocuted in 1937, K.B.W. launched the now internationally-known A.R.R.L. policy of "Switch to Safety."

Operated W1EH

His own station, W1EH, was a picture of efficiency, neatness and flexibility. He had many friends throughout the world and nothing would give him greater pleasure than to chat with them when the toil of the day was over.

By
ROTH JONES
VK3BG

The tale is told that K.B.W., who was an expert at the automatic "bug" key, spent months at practice on the automatic electronic key before he would use it to key his own transmitter—an indication of the pride he had in his equipment and its operation.

A keen student of propagation, he built a rhombic antenna last year which put his signal amongst the world's most consistent DX stations. But he was balanced. He did not spend all his time on the air. He did his share of research on the ultra high frequencies and was recognised as one of America's authorities on the ultra-highs.

Just prior to his death, K.B.W. wrote a paper for the 1948 National Convention. It was entitled "The A.R.R.L.—your organisation." Unfortunately he did not live to read it but it was presented by the vice-president (Mr. J. McCargan). Tracing the history of the organisation with its democratic policies, the paper is recommended to any man who has ever turned on a radio dial. It was published in the November issue of QST.

As secretary and manager of the A.R.R.L., K. B. Warner was known and revered by amateurs throughout the world. (Q.S.T. Photo)

K.B.W.'s history started back in 1915 when he operated 9JT, a 500-watt fixed spark transmitter with the then proud boast of a 12-mile radius. Two years later he was editor of QST and retained the appointment until his death. His work in those three decades has made the A.R.R.L.'s history virtually the life story of himself. In the early 20's he led the campaign for CW while many others fought for the retention of the spark.

Worked With Early Experimenters

In 1921 he sponsored the trip to Scotland by Paul Godley, the first man to receive American amateur signals across the Atlantic using the then "low" frequency of approximately 2000 kilocycles. The next year K.B.W. was working with John L. Reinartz and Fred H. Schnell, the first men to conduct

(Continued on page 47)

3 WATT CATHODE FOLLOWER AMPLIFIER

Details of an interesting amplifier circuit which was originally designed to determine the merits of cathode followers. Employing a special pick-up and record equaliser network, this design features a cathode follower driver and output stage, resulting in a high-quality performance unit which is admirably suited for use in the average home.

Much has been written lately on the subject of high fidelity amplifiers, which in conjunction with good quality pick-ups and speakers, are capable of very fine performance. However, many enthusiasts who have built reproducers of this type have frequently found that the overall performance is decidedly limited by the quality of the records available.

An audio system having a uniform response of the order of ± 1 db to 12 kc. not only reproduces all the scratch frequencies on the record, but also any combination tones formed between the scratch frequencies and the musical harmonics due to the non-linearity in the pick-up. It is these combination tones which cause the objectionable *"edge"* and *"fuzziness"* of music from average quality records played on a high fidelity reproducer, using anything but a completely distortionless pick-up.

Response to 7000 C.P.S.

The amplifying system described herein makes no pretences of being in the high fidelity class. It was constructed about two years ago and no thought was given to its use on wide range recordings, for the simple reason that it will be years before these are commercially available in sufficient numbers to replace existing records which have very little above 6000 c.p.s. on them. Even so, the system has a fairly uniform high-frequency response up to 7000 c/s, but as this is now considered too high for most purposes it is intended to instal a filter between pick-up and amplifier to provide a sharp cut-off at 5500 c/s. This will then effectively remove any needle resonance effects.

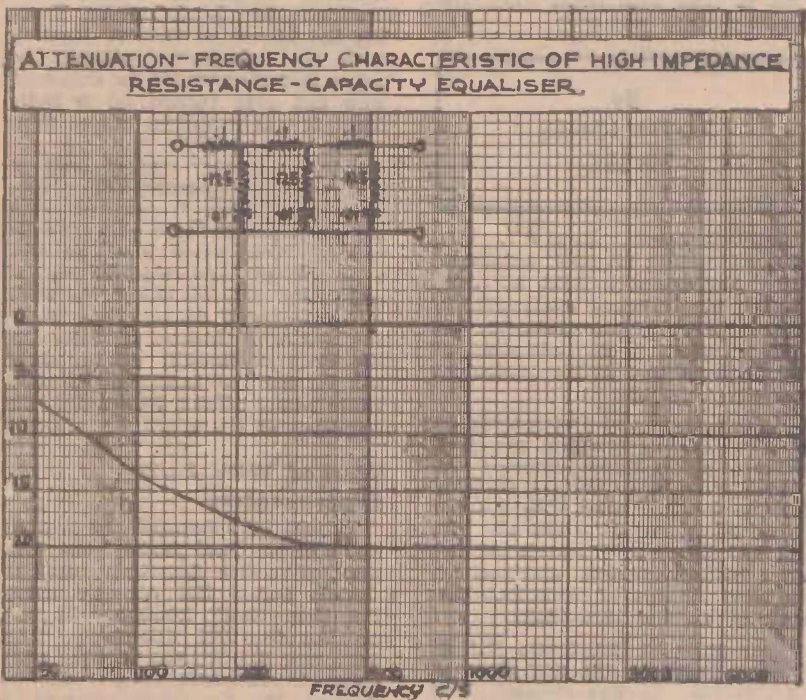


Fig. 2. This graph shows the attenuation characteristics of the record equaliser.

In this first article it is proposed to discuss only the amplifier section, which is rather interesting as it is of the cathode-follower type, leaving the speaker system and method of baffling until the following article.

Pick-Up

The pick-up used is a good quality audak magnetic type, having an impedance of 600 ohms. This takes standard size removable needles and exerts a weight of approximately 50 grams on the record. The use of removable needles is an important feature especially after playing some recent records whose surface can only be described as *"road metal."*

Equaliser

Since magnetic pick-ups are generally deficient in bass, it is necessary to equalise for the pick-up characteristics, as well as compensating for the constant amplitude recording characteristic. Thus the equaliser may be considered as two parts—the pick-up equaliser and the record equaliser. In this particular case, the pick-up equaliser consists of a single section *L* type network in the 600 ohm line between pick-up and input transformer, as shown in the circuit diagram of figure 1.

It should be noted, however, that this particular equaliser does not fully compensate for the falling response of the pick-up at low frequencies. To do this would require an extra section in the equaliser, which in turn would increase its attenuation to the extent of necessitating higher gain from the am-

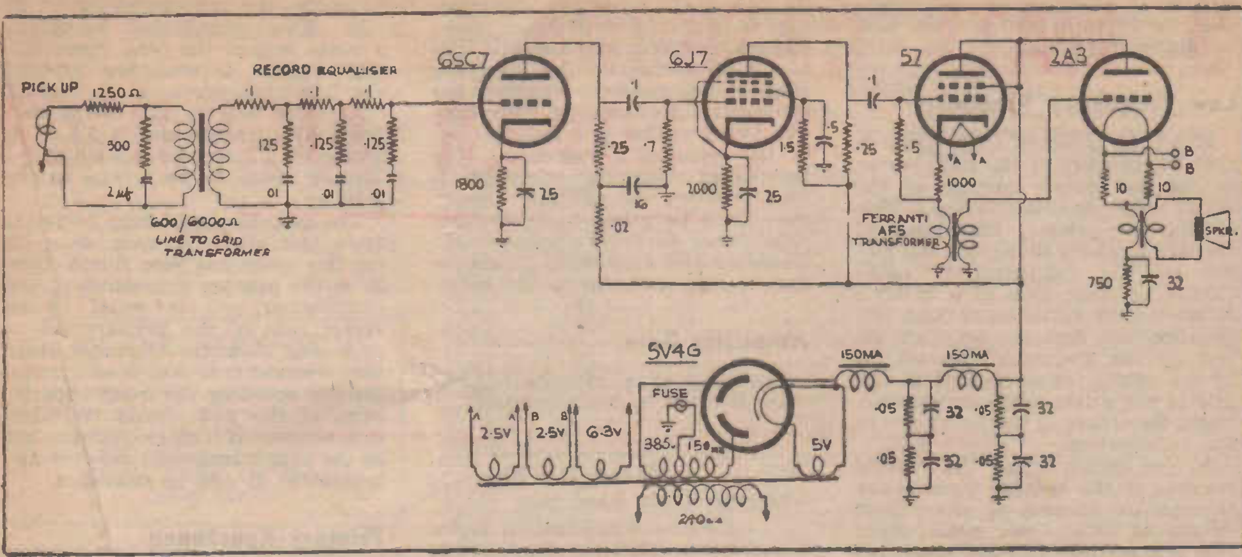


Fig. 1. Schematic diagram of the experimental amplifier. The use of cathode followers in the driver and output stages ensures high quality, low distortion reproduction.

plifier if full power output is to be maintained. To date, no alterations have been made in this direction.

It should be mentioned that whilst listening tests have given pleasing results, noticeably better bass is obtained by feeding radio programmes from a tuner into the amplifier. Consequently, some readers may prefer to improve the low-frequency response of the pick-up.

Referring again to figure 1, the record equaliser is connected between the secondary of the input transformer and the grid of the first valve. This equaliser consists of a three section resistance-capacity network of a high impedance type originally designed for use with a crystal pick-up.

Recording Characteristics

It is well known that to avoid too large a groove amplitude at low frequencies on disc recording, it is necessary to record on a constant amplitude characteristic below a certain pre-determined frequency, while a constant velocity characteristic may be used above that frequency. The choice of cross-over frequency is rather arbitrary. British practice is to use 250 or 300 c/s, while in America there is considerable variation to the extent of using cross-over frequencies of 400 or even 800 c/s.

Recording at constant amplitude means that the output voltage of a velocity operated device such as a magnetic pick-up is attenuated to the extent of 6db per octave below the cross-over frequency. Therefore to obtain linear response, it is necessary to incorporate an equaliser, having an attenuation-frequency characteristic which is the inverse of this. Figure 2 shows the characteristic of the equaliser under discussion. In view of its simplicity and low cost, coupled to the fact that the maximum attenuation was limited to 20 db, this unit gives a characteristic which is a reasonable approximation to the desired curve for British recordings.

It is important to note that this equaliser network is designed to operate into an infinite impedance. Hence the output if connected across the output of the equaliser will alter its characteristics. It will be observed from figure 2, that at frequencies above 400 c/s the network has a constant attenuation of 20 db. This means at the middle and high frequencies the output of the equaliser is only a tenth of the input. Hence the use of this equaliser necessitates an extra 20 db gain in the amplifier. This can be easily achieved by using a general purpose triode pre-amplifier having a stage gain of 10.

Pre-amplifier 6SC7

In the amplifier under discussion a high-mu triode 6SC7 was used to compensate also for the loss incurred in the pick-up equaliser. When the pick-up is fully equalised it will probably be necessary to use a pentode in this position. This serves to illustrate the fact that complete equalisation involves a large proportion of voltage drop in the equalisers, and necessitates a considerable amount of pre-amplification. The use of so-called bass-boosting tone controls is from experience, not generally satisfactory. Unless these units are very carefully designed they are not sufficiently selective in their action, and tend to boost too wide a range of frequencies.

By
H. L. HARVEY
Engineering Department,
University of Queensland.

Main Amplifier

Regarding the 6SC7 as a pre-amplifier, the main amplifier consists of a 6J7 pentode, resistance coupled to a triode connected 57 cathode follower driver, which in turn is transformer coupled to the 2A3 cathode follower output valve. This amplifier was originally built as an experimental unit at the time when much discussion arose as to the uses and quality of cathode followers.

In some instances, elaborate claims were made to the effect that good results could be obtained from a cheap audio transformer when used in the cathode follower circuit. A number of transformers were subjected to square wave and listening tests in this amplifier, and it was found that although the cathode follower connection gave considerable improvement over plate loading, a cheap audio transformer can in no way approach the quality obtainable with resistance coupling.

In short, the quality of any transformer coupled amplifier depends ultimately on the quality of the transformers used. Of the limited number of transformers then available, the Ferranti AF5 gave the best results in this amplifier.

Low Frequency Response

It will be observed from figure 1, that the primary of the transformer carries the direct current of the driver valve—in this case 6 m.a. This reduces the primary inductance of the AF5 to about 80 henries, but owing to the comparatively small change of stage gain of a cathode follower with variation of load impedance, this does not seriously affect the low frequency response. A 50 c/s square wave applied to the grid of the driver valve showed only slight distortion at the secondary of the transformer.

In the output stage, the loading consists of the speaker transformer through the primary of which flows 60 ma of DC. Once again, since this is a cathode follower stage, reduction of transformer primary inductance does not seriously affect the gain at low frequencies.

It is well known that a cathode follower operates at 100 per cent. negative feedback, but in the case of transformer loading of a valve in such a circuit, the feedback occurs essentially only on the primary side of the transformer. Any distortion introduced in the secondary can enter the feedback loop only by reflection into the primary.

This means that for the feedback to give optimum reduction of distortion, the transformer should have its secondary closely to the primary —i.e., the windings should be sectionalised and have low leakage inductance. This applies to both interstage and output transformers.

Constructional Hints

The following practical points should be of interest to those who may intend to build up this amplifier. The heater of the 57 is placed on a separate 2.5 volt winding on the power transformer, and the circuit left "floating." This is to prevent too high a potential difference between heater and cathode which would occur if the heater of the 57 were earthed, since the peak signal voltage between cathode and earth is about 70 volts.

The 2A3, of course, requires a separate heater circuit. The bias for this valve is obtained in the usual manner with a 750 ohm resistor in the filament circuit. Actually, the resistance of the speaker transformer primary contributes to the bias although this resistance is only 70 ohms.

The bias of the 57 is made independent of the primary resistance of the audio transformer by means of the connection shown. This also provides for a very high input impedance. For if the gain of the 57 from grid to transformer primary is 0.9, only about 0.1 of the input voltage from grid to earth occurs across the grid resistor, which means that so far as loading of the preceding stage is concerned the 57 driver has an input impedance of something like 10 times the grid resistor—i.e., of the order of 5 megohms. If a metal-clad coupling condenser is used between the 6J7 and the 57, care must be taken to ensure low capacitance between electrodes and frame of the condenser, otherwise, loss of high frequencies will occur.

Amplifier Gain

The gain of a cathode follower stage is given by the formula:

$$M = \frac{u\ Zc}{Zc\,(u+1) + Rp}$$

where M equals stage gain

u equals amplification factor
Rp equals plate resistance of the valve.
Zc equals the cathode load impedance.

In the case of the 2A3 operating in Class A into a load impedance of 5000 ohms—actually this is twice the recommended value, but is satisfactory—the gain works out to be 0.78. This means that to obtain 3 watts output, the peak input voltage applied between the grid of the 2A3 and earth must be 157 volts. The step up ratio of the Ferranti AF5 transformer is 3.5 to 1. Hence the 57 must be capable of delivering about 45 peak volts to the primary.

The gain of the 57 may be found from the above formula once Zc for this stage has been found. Here Zc is the primary impedance of the transformer, and is equal to the vector sum of the primary resistance and inductive reactance since the secondary is an open circuit. Strictly speaking the input capacitance of the 2A3 should be taken into account at high frequencies, but as the gain calculations are only approximate, it can be neglected.

Primary Reactance

The primary reactance can be calculated for any frequency from the formula:—

$XL = 2\pi FL$, where L is the primary inductance. For the transformer in this particular circuit L equals 80 henries. At 50 c/s, XL works out at approximately 25,000 ohms The primary resistance is 2400 ohms. Hence,

$Zc = \sqrt{(25000)^2 + (2400)^2}$

which is near enough to 25,000 ohms.

Substituting this value for Zc in the gain formula above, we find the gain of the 57 is 0.935 (Taking u =20 and Rp=10,000). Thus the peak input voltage necessary between the grid of the 57 and earth is 48 volts. Note that only a small fraction of this voltage occurs between grid and cathode; hence the valve is not overloaded as it may appear at first sight to anyone not familiar with cathode followers.

IN THE NEXT ISSUE

The concluding part of this article dealing with the speaker system and construction of the acoustical labyrinth will be detailed in the April issue.

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The 48 volts is well within the output capabilities of a 6J7 with a B plus voltage of 250 volts and a 0.25 meg plate load resistance.

Taking the gain of this stage as 125 (obtained from data sheet on resistance-coupled pentodes) it is seen that the peak input voltage to the main amplifier should be about 0.38 volt to full output. The pre-amplifier must be able to deliver this voltage, and its gain will be determined by the output voltage available from the pick-up, and the voltage drop incurred in the equalisers.

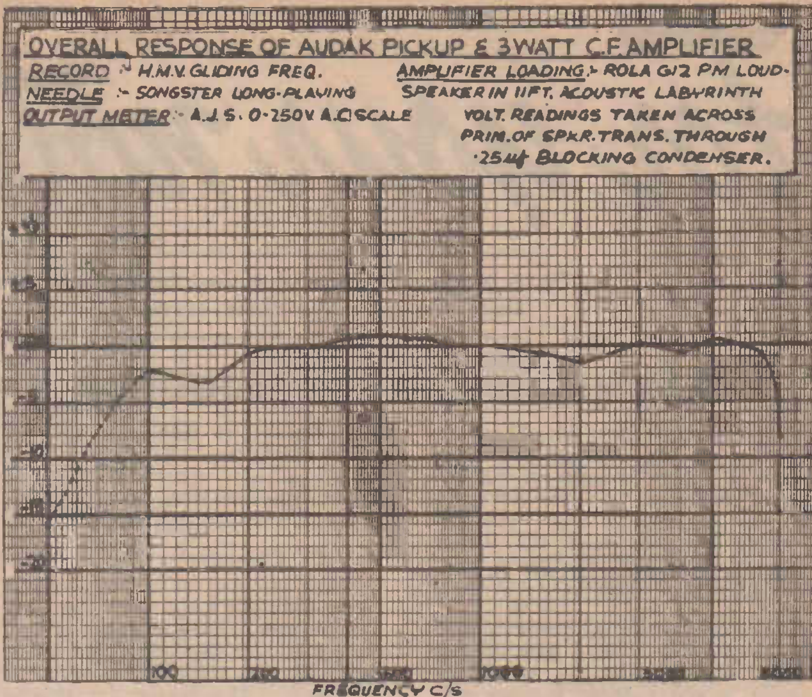


Fig. 3. Overall response of the amplifier.

Distortion

It will be observed that in the main amplifier two of the three valves are operating under conditions of heavy inverse feedback, hence distortion should be fairly low. Unfortunately, it was not possible to carry out any distortion

(Continued on page 46)

For your note book

A page of radio servicing hints and notes of practical value to the radio serviceman and technician.

VOLUME CONTROL TROUBLES

Volume control troubles are so frequent that they occupy a position near, if not at the top of all servicing problems. The reason for this is that so long as high resistance control must be used, the carbon type or something like them must prevail, and consequently will wear out.

The main faults that develop with these controls is that they become open, change resistance as the receiver is operated or become substantially shorted. At some place after a period of operation, the control will frequently show, or rather reveal aurally, signs of wear and as this spot is the weakest it will be the first to give and so an open control will result.

Pencil Makeshift

In cases such as this, some service men frequently take an ordinary lead pencil and draw a line on the resistance base, thus making the unit operative once again. Whilst this practice may be satisfactory in an emergency, it is only makeshift and should never be left as a permanent repair. For a start the repair will not last, with a recurrence of the same trouble at an early date, but the most important factor is that the taper of control is likely to be seriously changed by this pencil line restoration.

For instance in the case where a control that should have 500,000 ohms total resistance, the pencil line total may be anything, hence wrong, and usually the service man who makes this type of repair is not the type who stops long enough to determine the resistance value he may have produced.

Exact Replacement

Consequently the best procedure in these cases is to replace the defective volume control. In doing this make sure an identical type is used, so that if a special taper is required, the same taper will be duplicated. This is most important because for some uses the control has great resistance change over a small angular displacement of the control knob, for other uses the change is more gradual or may be in the opposite direction. The control is therefore right only when the resistance changes with the correct increment and in the same direction.

A.V.C. Circuits

When the control is used in a receiver that has A.V.C., and the variable resistor is related to the A.V.C. circuit in any way, then the metal case of the control should be grounded. The reason for this is that high degrees of oscillation are sometimes obtained at r-f or i-f levels and the simple procedure of grounding this case will often clear up the trouble. Also this grounding of the case is essential where the control has an a-c switch attached. otherwise there is the possibility of the audio frequencies having a 50 cycle hum frequency superimposed.

Slipping Dial Cords

Usually the dial pointer on most dials is moved by means of a cord drive, and it will be found that this cord eventually loosens or expands sufficiently so that the condenser moves but not the dial pointer. Here is the remedy for this condition.

Prepare a solution of resin and petrol. Brush this on to the cord revolving the dial at the same time. The petrol will then dry out leaving the resin on the cord, and this will usually provide sufficient friction to prevent any further slippage.

Grid Cap Repair

Frequently the experimenter finds that the grid cap of a valve becomes loose or comes off after the valve has been used for some time. This can be repaired in the following manner. Take the cap in a pair of pliers, clean the inside and melt any old solder out of the hole at the top.

Next wind a piece of wire around the stub of wire coming out of the top of the valve and solder in place using as little heat as possible. Push the wire through the top of the grid cap, and fill the cap with a fast drying cellulose cement. Press down on the top of the valve and leave to dry.

After the glue is dry, cut off the excess wire and solder lead to the cap. Clean off any excess cement, and an apparently useless valve is again ready for operation.

Repairing Fine Wires

When breaks occur in radio coils and other components wound with thin wire leads, it is often difficult to resolder the broken ends. When carrying out such a repair, a small piece of copper shim will be found very handy.

Tin the copper shim and place under the broken ends of the wire and solder the leads on to it. To prevent the soldering iron from picking up the shim, hold it down on to the bench with a matchstick. If it is necessary to insulate the shim, cover it with a few drops of tar, nail polish, or shellac and allow to dry.

Tip Jacks

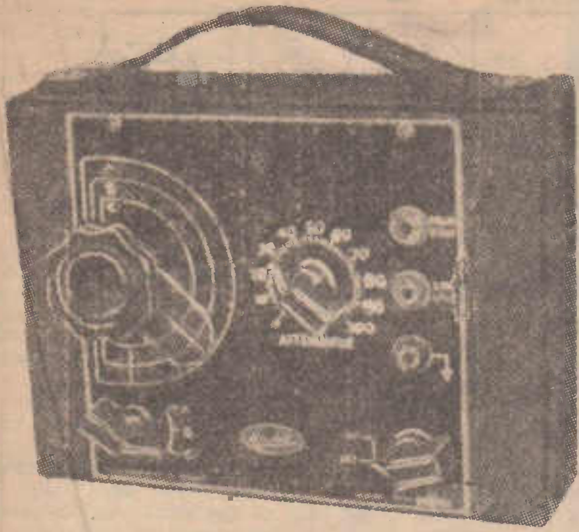
An assortment of tip jacks can be easily obtained from old valve bases. Simply break up the valve base, taking care not to damage the pins, and after heating each pin, blow through it to remove all solder. By using different types of bases, various size tip jacks can be made.

Cleaning Crackle Finish Cabinets

The dust collecting crackle finishes frequently used on various types of radio equipment can be readily cleaned with a solution of carbon tetrachloride and a few drops of oil. For best results it will be found that about 10 drops of a light machine oil to one ounce of carbon tetrachloride will prevent the metal surfaces from drying a lustreless color. Apply the solution with a piece of soft absorbent cotton and then wipe off with a dry soft cloth.

Frayed Test Leads

Often it will be found that the insulation on test leads wears very quickly at the point where the wire enters the prod handles. This can be overcome by reinforcing them with two or three coats of duco cement. Allow each coat to dry before applying the next, and it will be found that this will considerably prolong the life of the leads.



BATTERY OPERATED OSCILLATOR

Here is the companion unit to the multimeter described in the last issue. Designed by Radio Equipment Pty. Ltd., this oscillator covers three frequency ranges and will enable the rodio serviceman to carry out all normal receiver adjustments.

In our last issue a handy multimeter was detailed and now in this article we describe the construction of another piece of test equipment —namely the oscillator. This unit, in conjunction with the multimeter forms the basic servicing equipment for many radio servicemen and will permit practically all common service checks to be readily carried out.

The oscillator is simply a device for placing into the input stage a signal similar to that received when the set is operating under normal conditions. In this manner the unit can be used to align and check the various circuit stages so as to ensure the maximum results being obtained.

Covers Three Ranges

This particular unit covers three main ranges namely—"A" Band, 160-490 kc., "B" Band, 550-1600 kc., and a "C" Band 16 to 45 metres. Thus the "A" Band will allow all common I-f channels to be checked, the "B" coil covers the standard broadcast band and is used for receiver alignment, whilst the "C" coil covers the most popular short wave bands as usually found in commercial receivers.

In the kitset, it will be found that some of the components are already supplied mounted and soldered in place. For example the dial has been set and all coil iron cores and trimmers have been preset at the factory. It is essential that these seals should not be broken or any adjustments made to the coils. Each coil unit has already been checked with a highly accurate instrument after assembly, and consequently there is no complicated calibration for the constructor to worry about.

Assembly and Wiring

The first step in wiring the oscillator is to connect the two torch cells in series with a small length of hookup wire—about two inches will be ample. Next slip the two cells under the clips provided with the positive ends (brass caps) towards the top of the panel. Then mount the switch near the batteries at the bottom of the case with the lugs pointing to the top of the case.

The potentiometer is next mounted with the lugs pointing towards the gang condenser. Now solder a lead from the bottom or the negative end of the lower cell to the lug closest to the batteries on the small switch. If any difficulty is experienced in soldering to the bottom of the cell it should be scraped lightly first when it will be found to solder readily.

Next solder the long single wire from the coil unit on to the positive cap of the top torch cell, making the wire long enough to lay flat across the back of the panel all the way. This completes the filament wiring of the oscillator.

The remaining wiring is all associated with the attenuator and if the position of the leads is carefully studied when they are put in and kept as short as possible the attenuator will work smoothly with a minimum of leakage. First bend the top lug of the potentiometer flat and solder it on to the metal cover. Next solder a lead from the earth

PARTS LIST

- 1 Metal case with lid.
- 1 Coil unit.
- 1 Output lead.
- 1 battery switch.
- 2 "A" battery clamping strips.
- 1 "B" battery clamping strip.
- 1 leather handle with screws, etc.

CONDENSERS.

- 1 single gang.
- 1 trimmer.
- 1 .01 mfd. tubular.
- 2 .0005 mfd. mica.

RESISTORS.

- 1 5 meg. ½ watt.
- 1 2000 ohm. potentiometer.
- 1 .025 meg. ½ watt.
- 1 5000 ohm. ½ watt.
- 1 50 ohm. ½ watt.

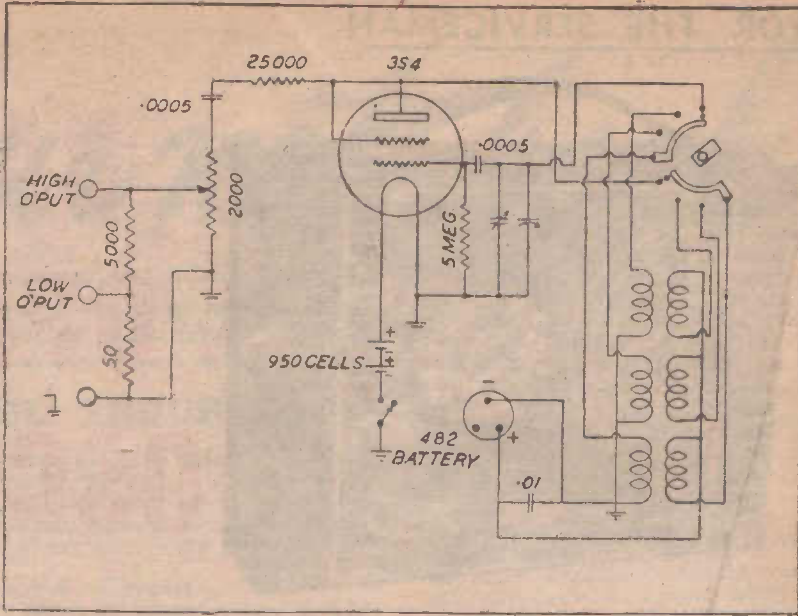
BATTERIES: 2-1.5 v. torch cells; 1-45 v. B battery, with battery plug.

VALVE: 1-3S4.

SUNDRIES: 3 pointer knobs, 4-self tapping screws, 3 tip jack sockets with nuts, etc., 1 turning knob and pointer, 1 brass label, hook-up wire, solder, nuts and bolts, etc.

socket to the closest point on the potentiometer cover. Both of these soldered joints should be on the side wall of the cover so as not to interfere with the mounting of the 45 volt battery.

The other wire to put in is one from the HIGH OUTPUT socket to the centre of the potentiometer. Next solder the 5000 ohm resistor between the HIGH OUTPUT socket and the LOW OUTPUT socket and the 50 ohm resistor from the LOW OUTPUT socket to the earth socket. Then connect one end of the .0005 mfd condenser to the remaining lug on the potentiometer. The other end is soldered to the 20,000 ohm resistor which is mounted on the switch.



The circuit diagram for the oscillator which is a simple but efficient arrangement.

Recheck Wiring

Recheck all the wiring and if it is found to be correct place the 45 volt battery in position. Screw the metal strip firmly on the gang condenser so that it lies across the battery, holding it in place. After that the three pin plug is inserted into the socket in the top end of the battery. If the 3S4 valve is placed in the socket and the oscillator turned on it will now function.

All that is left to do before screwing the instrument in the box is to fasten the handle to the box with the nuts and bolts provided and slip the sheet of prespahn along the top of the box to come between the negative end of the torch cell and the case. Finally put on the knobs and tighten them in place.

Now that the oscillator is built, check the wiring and construction very carefully, to ensure that no solder has run down under the various lugs or potentiometer as a short circuit at any of these points will prevent the instrument from functioning.

As mentioned earlier, the coil unit is supplied already adjusted and correctly lined up, and consequently it should not be necessary to make any further adjustments to this.

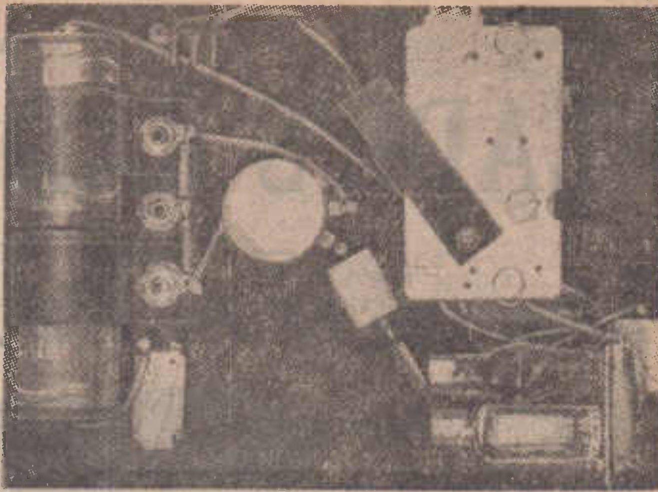
However if for some reason it should ever be necessary to recalibrate the oscillator, the coil iron core positions are as follows. Looking at the end of the coil bracket with the panel upright, the "A" band iron core adjustment is just above the 3S4 socket, the "B" band iron core is beside the "A." closest to the panel, and the "C" band iron core is beneath the "B" iron core nearest the socket.

The iron cores affect principally the low frequency end of each band, so that any adjustments should be made with the tuning condenser plates almost fully in. The trimmer should be set at the higher frequency end of "A" band, preferably on 455 kc. However these adjustments should not be necessary under normal circumstances.

★

This photograph shows the location of most components. The B battery fits into place between the two torch cells. It is held in place by the metal strip screwed on to the gang

★



Using the Oscillator

Apart from alignment, an oscillator of this nature can be used for several other purposes almost as important in radio service work. Its uses are set out below:—

(1) **Alignment of i-f and r-f circuits.**
(2) **Adjustment of dial tracking.**
(3) **Checking A.V.C. Characteristics.**
(4) **Testing valve and circuit components under working conditions.**
(5) **Signal Tracing.**

To enable the user to obtain the maximum results from the instrument, the abovementioned tests will be briefly described.

Receiver Alignment

The first point in aligning a superheterodyne receiver is the adjustment of the intermediate frequency transformers. To do this the *"hot"* (red) lead from the oscillator is connected to the grid of the i-f amplifier, whilst the earth lead connects to the chassis earth. Should the receiver contain two i-f stages, then the lead should be connected to the second i-f amplifier.

Switch on the oscillator, setting the dial to the required intermediate frequency and the final i-f transformer is now adjusted for maximum output. Then transfer the hot lead to the first i-f amplifier on the converter grid, and adjust the i-f transformer for maximum output. In carrying out this operation in receivers fitted with A.V.C. the signal input should be kept as low as possible to prevent the A.V.C. action from interfering with the correct alignment.

Recheck the i-f's and then transfer the oscillator lead to the aerial terminal. Tune the oscillator to a frequency of 1400 kc. and tune the receiver to this signal. In this position the oscillator, any r-f and the aerial trimmers should be adjusted for maximum results. Retune the oscillator and receiver to 600kc. and adjust the padding condenser. Recheck the 1400 kc. adjustment.

Dial Adjustment

The adjustment of the dial is normally carried out as the receiver is being aligned. With the oscillator supplying the correct frequency the oscillator trimmer and needle pointer are adjusted so that the correct frequency setting will be registered.

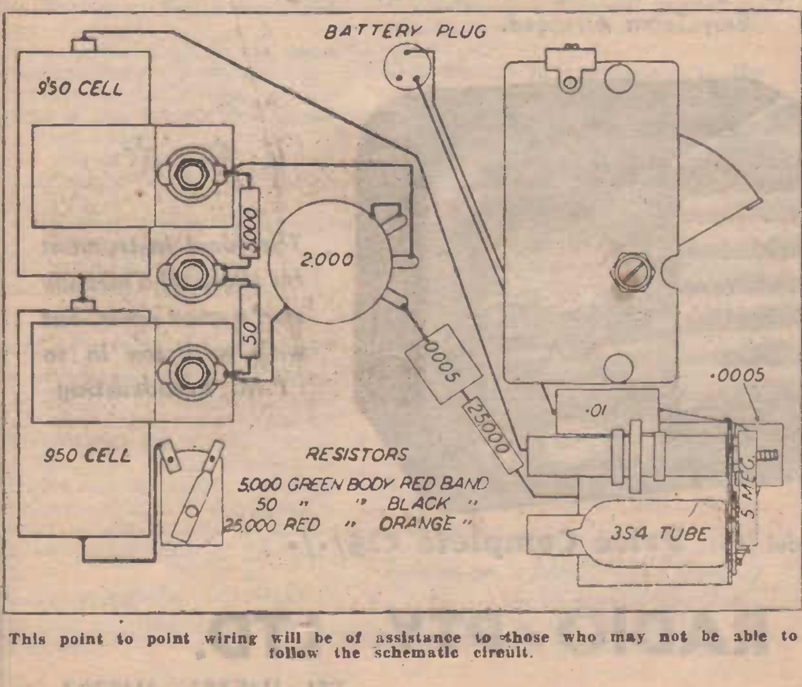
Checking A.V.C.

The action of the automatic volume control can be easily checked by feeding the signal into the aerial and earth at various frequencies and noting the effect of the A.V.C. voltage on any of the valves controlled by it. In the case of a valve using a bias resistor in the cathode circuit, it is only necessary to place a meter across the cathode resistor and increase the oscillator signal from zero to maximum and note the effect on the voltage developed across this resistor.

If the automatic volume control is working correctly, the voltage registered by the meter will decrease as the signal strength is increased. The amount of A.V.C. voltage can be readily judged by the reduction in bias voltage. This action should be checked on all valves controlled by the A.V.C. voltage.

In valves such as octodes and pentode converters, the majority of the cathode current is made up not by the ordinary plate current but by the screen and oscillator plate current, and consequently the effect of the A.V.C. will be hardly noticeable with a meter connected across the resistor in the cathode circuit. In this case, as with valves which are biased by a back-bias system, it is necessary to insert a milliammeter

(Continued on page 47)



This point to point wiring will be of assistance to those who may not be able to follow the schematic circuit.

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MISCONCEPTIONS ABOUT RECORD WEAR

This authoritative article gives a thorough analysis of the causes of record wear, and should be of great interest to all amplifier enthusiasts and owners of record libraries.

The life expectancy of phonograph records is a subject which is under constant discussion; to the person who has invested a considerable sum in a record library much of which is irreplaceable, record wear is a topic of more than academic interest.

It is regrettable that so much inaccurate information has been disseminated about record and stylus wear. A great deal of the published "data" on record wear and stylus life, unfortunately, has originated in the optimistic imagination of some uninformed copywriter. This situation gives rise to some of the following commonly-held beliefs:—

1. **That a hard reproducer stylus wears records faster than a soft one.**
2. **That a soft reproducer stylus wears records faster than a hard one.**
3. **That shellac records wear faster than vinylite.**
4. **That vinylite records wear faster than shellac.**
5. **That tracking pressure is the only important factor in record wear.**
6. **That tracking angle is the most important factor in record wear.**
7. **That lateral compliance of the pickup is the determining factor in record wear.**
8. **That vertical compliance is the determining factor in record wear.**
9. **That a large stylus radius imposes less wear on records.**
10. **That a small stylus radius imposes less wear on records.**

Factors Affecting Record Wear

The above statements all represent an attempt to reduce the problem of record wear to a simple one-dimensional affair. As a matter of fact, the actual problem is so complex and the factors involved so numerous that it is not possible to predict record life without specifically evaluating ALL of the following:—

1. **Record material.**
2. **Spectral distribution of recorded energy.**
3. **Velocity angles of the record grooves.**
4. **Shape of the groove cross-section.**
5. **Relation of groove cross-section to shape and polish or reproducer stylus.**
6. **Lateral and vertical mechanical impedence at stylus tip at all frequencies.**
7. **Tracking pressure of reproducer.**
8. **Lateral and vertical warpage of the record.**
9. **Lateral and vertical pivot friction in reproducer arm.**
10. **Tracking error and head offset of pickup arm.**
11. **Lateral and vertical turntable vibration.**

An attempt has been made to arrange the parameters in the approximate order of their importance to record wear. They are not all independent variables, so it is impossible to discuss each one without constant reference to the others.

Actual Process of Record Wear

Record wear is a change in the character of the record groove resulting in one or all of the following:—

1. **A change in appearance of the record surface, visible to the unaided eye.**
2. **An increase in background noise.**
3. **An increase in distortion.**

It seems to be fairly certain that the actual process of record wear is accomplished by one or all of the following:—

1. **Frictional erosion of the groove walls by a rubbing action between the stylus and the groove.**
2. **Deformation or crumbling of modulation cusps by dynamic forces between the stylus and the groove.**
3. **Shearing of modulation cusps by sharp edges on the reproducing stylus.**
4. **"Rolling in" of surface dirt between the stylus and groove walls.**

Forces on a Modulated Groove

In order to appreciate the complex nature of the motion at a reproducer stylus point, it is good to review the basic mechanics of the vibrating system of a record reproducer.

The forces set up at the stylus top in Fig. 1B are determined by the constants of the elements in the system and the nature of the motion imposed on the stylus tip. Referring to the diagram, the useful motion of the reproducer is the deflection of the compliance C1 denoted by X2. This deflection is equal to the sum of the forces at both ends of the spring times the compliance of the spring.

Imagine the point marked "stylus tip" being vibrated rapidly in the direction of X1. At high frequencies the principal force is that required to accelerate the mass M2.

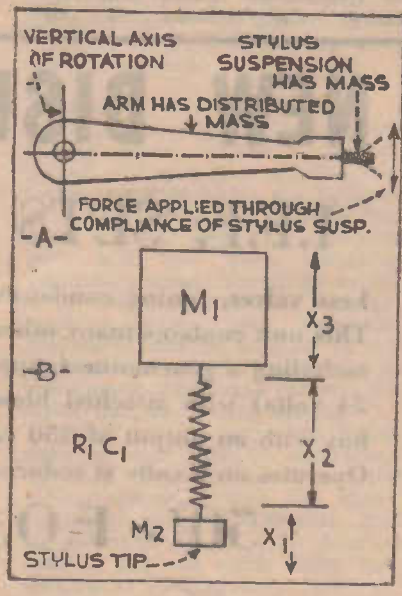


Fig. 1. In (A) pickup arm and stylus and (B) equivalent mechanical circuit diagram. Mechanical forces are designated as listed below. M1—Moment of inertia of pickup arm; M2—Moment of inertia of stylus suspension; C1—Compliance between stylus support and arm; R1—Damping of system; X1—Displacement of stylus; X2—Displacement of compliance; X3—Displacement of mass. X1—X2 X3. X2 is the useful motion in the reproducer. NOTE: This diagram applies equally well to vertical or lateral motion at the stylus point, except for a change in values of the parameters. For vertical motion, M1 and C1 will usually be lower and M2 higher than for lateral motion.

This force equals M2a where a is the acceleration which the record groove imposes on the stylus. As the frequency is lowered, we approach the point where M2 is resonant with C1. At this frequency the mass M2 moves quite easily, and the force applied by the record groove is determined only by the damping R1. This damping force is equal to R1V where V is the velocity of the motion applied to the stylus point.

As we go lower in frequency we find that the stiffness of spring C1 is the controlling factor. This force is C1X2. As we approach the frequency where M1 and C1 are in resonance we find that the amplitude X2 builds up rapidly to a maximum value limited only by the damping R1 and limits stops on the stylus supports. Below resonance M1 and M2 move together and there is no deflection of X2 to produce useful output from the reproducer.

Forces on Record Groove

The point of this rather crude discussion of the dynamics of pick-up action is to assist the reader to visualise the reaction forces on the record groove. At high frequencies even a groove with very small displacement can have a high acceleration, because the displacement is multiplied by frequency squared to obtain acceleration. At low frequencies (above arm resonance) the stiffness of the stylus suspension is the most important consideration. The ability to track bass passages well is directly related to this characteristic.

As the frequency is lowered toward arm resonance, the output from the reproducer increases, but so do the forces on the record groove. These forces reach a maximum at resonance, where they may become extremely high. If the amplitude of oscillation is high enough to cause hammering against the stops of the stylus support, the record walls will quickly be broken down. Of course, the actual value of the force depends on the mass of the arm, so a light arm has some advantage in this respect.

On the other hand, resonance will be reached at a much higher frequency with a light arm, so excitation will be provided by frequencies within the desired range of reproduction. This will give rise to a situation where the groove forces reach a peak on some particular bass note, which condition may cause groove breakdown at that frequency.

Frictional Erosion

It now becomes possible to discuss in some detail what actually goes on as the groove wears. Wear in a blank groove when no vibrational forces exist can only occur by breakdown due to static load, or by actual abrasion from a rough stylus point.

The forces mentioned in earlier sections are applied to the groove wall by a spherical stylus in the ideal condition. The unit load, therefore, is dependent on the actual area of contact. This area is largest for a worn stylus, so we find that the unit stress on the record material is least when the blank groove is played with a worn stylus.

This is by no means intended to indicate that stylus wear is advantageous, although in the early phonograph days it was the wear on the steel needle which made the phonograph feasible at all because of the enormous tracking pressure of the reproducers. The only thing which made possible repeated playings of a disc was the fact that both the recorded amplitude and the high-frequency content were low. A modern high-level record played on an old acoustic phonograph will not survive the ordeal.

With pick-up pressures of one ounce or less, even a perfectly spherical stylus will not subject a shellac record groove to more stress that it can withstand, due to static forces alone. Some elastic deformation will occur in vinylite, however, and even more in instantaneous lacquer.

These latter materials have good plastic memory, and the grooves do not seem to be any the worse for wear after being played with a highly polished stylus even with considerable pressure. Materials like lacquer and vinylite are easily scratched, and the least roughness on the stylus will act like a file in the grooves. Shellac is not nearly so easily abraded, although a chipped jewel stylus will ruin any groove.

Lacquer and vinylite are particularly susceptible to having surface dirt embedded in the grooves. This dirt is rolled in under the pressure of the stylus and evidences itself as an increase in background noise, particularly *"clicks and pops."*

Tests made indicate that black grooves on shellac records will wear indefinitely with a smooth spherical stylus which does not exceed one ounce pressure. Turntable vibration can alter the conditions sufficiently that wear will show in regular patches, indicating that the peak forces at such places have greatly exceeded the tracking pressure. Certain low-priced record changers show considerable vertical vibration which produces wear of this description.

Vinylite and lacquer, on the other hand, do not show these wear patches under the same conditions. This would indicate that the compliance of the record material prevents the high peak accelerations which exist with the hard shellac. The softer records do show a general increase in noise because of dirt, however.

Dynamic Wear

By far the most significant cause of wear is the dynamic action of the stylus in the grooves. The mechanism of wear is the same as for static forces, but it occurs only at certain parts of the record, depending on the shape of the groove. What happens on shellac is fairly certain. It can be seen through the microscope in progressive stages.

A spherical stylus in the groove produces dynamic forces, and if the resultant force exceeds momentarily the elastic limit of the record material, the material deforms. Since shellac is brittle, it crumbles away completely. The breaking away of the piece which was under stress permits the stylus to drop down into the groove a little deeper, eventually increasing the bearing area of the stylus by contact with the groove bottom. At this point with a low-mass reproducer the wear apparently stops, because the peak unit stress no longer exceeds the elastic limit of the shellac.

An interesting fact about this type of wear is that it does not produce any apparent change in quality of the reproduced sound, although it can be seen as a light streak on the surface of the record. This type of wear occurs more readily with the larger stylus radii (.003in. or larger) than with a radius of .0023 to .0025in. Of course, it can be seen that too small a radius, besides causing "skating" in the bottom of the groove, will concentrate the stress on the groove bottom with a worse effect on the quality.

It must be made clear that the foregoing discussion refers to high-frequency effects where the force required to accelerate the mass of the stylus mounting is predominant. It also applies both to vertical and lateral forces, and both must be considered at all times.

Effect of Stylus Tip

Since the metal and sapphire stylus tops acquire worn flats much more readily than does the diamond, this is probably the reason for the belief held by some people that diamonds wear records more rapidly than sapphires or metal tips. Although it is possible that visible wear might occur sooner with the diamond, audible wear, caused by actual widening of the groove at corners, will occur far more rapidly with a worn stylus.

The flats on the sides act as scrapers in attempting to negotiate sharp bends in the record track. When the record groove is widened the pickup will rattle at these spots. Another effect of a worn stylus, even in a perfect groove, is the distortion, which rapidly becomes unbearable at high frequencies.

At low frequencies, the amplitude of the groove swing determines the force applied to the stylus. If this force exceeds the instantaneous tracking pressure, the reproducer is said not to *"track"* and the stylus slips over the land adjacent to the groove. If this happens often enough the groove wall is broken down, and the result is a *"rattle"* on such bass passages. With most modern reproducers this is not a serious problem, however.

A similar effect results from too light a tracking pressure at high frequencies. Because of the slope of the groove wall the stylus may be forced upward under acceleration, which will cause rattling and hammering of the groove walls. This may actually cause more damage than if the tracking pressure had been slightly higher.

These dynamic forces mentioned in connection with shellac records do not reach such high values with vinylite or lacquer discs. The material itself is elastic enough to reduce the force applied to the stylus, although continual application of excessive force to the same points in the groove wall will eventually widen the groove and produce distortion and rattles.

Deformation of the groove walls indicates that the reproducer stylus does not follow the patch cut by the cutting stylus. It is obvious, therefore, that the resultant signal is not a true reproduction of the original cut. This is the reason high-level passages never sound as *"clean"* on lacquer or vinylite as they do on good shellac.

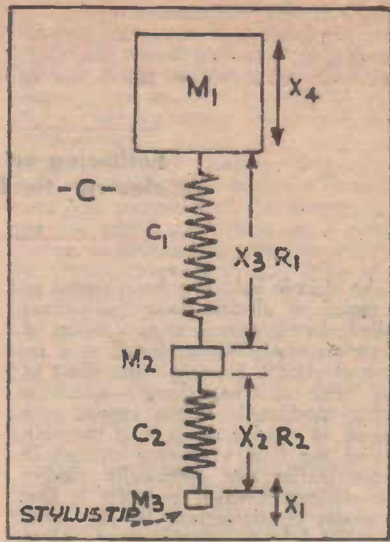


Fig. 1 (C). Equivalent mechanical circuit for magnetic reproducer. M1, M2, C1 and R1 are the same as in Fig. 1B. C2 is the compliance between the stylus and the moving system. M3 is the moment of inertia of the stylus suspension. R2 is the damping of the stylus support. In this case X3 is the useful motion of the system.

Lacquer and vinylite are much more easily cut by a worn playback stylus, which is another reason why only a highly-polished diamond should be used in a reproducer which must play all three types of material.

Summary

For minimum record wear a low moving-mass highly compliant pickup with a highly polished diamond stylus produces the best results. The pickup arm must be free from friction and the turntable level and free from vibration. Tracking pressure should be as low as possible, but is not the principal factor in dynamic wear. Some improvement can be effected at the expense of very high frequencies by introducing compliance between the stylus and the moving system.

Shellac records may show visible signs of wear with no deleterious effect on the output signal from the pickup, provided that the above conditions prevail. Vinylite and lacquer discs do not show wear as readily, but are much more susceptible to surface dirt.

Whereas a slightly worn stylus may have no particularly harmful effect on a shellac record, lacquer and vinylite are easily damaged under these conditions. A slightly worn stylus will produce high-frequency distortion even from an undamaged groove. A badly worn stylus will cut the grooves in places where the angles are sharp, producing serious rattling.

—Courtesy "Audio Engineering."

Basic Electricity and Magnetism

Following on from the previous article, the author discusses electric fields in more detail and shows the method of plotting lines of force.

An electric field may be regarded as a region of *electric force* (sometimes called electric stress), or as a region of *electric strain*. When viewed as a region of electric force it is the effect of the field on other charges which is being considered. When viewed as a region of electric strain it is the ability of the field to *induce* charges in other bodies and electrically modify the dielectric which supports it that is under consideration. In this latter case the field is regarded as a field of *electric induction*.

Terms used to describe an electric field when it is regarded as a field of electric force are *electric stress, electric field intensity*, or *electric field strength*.

Terms which signify that the field is being regarded as a region of electric strain are *electric induction, electric flux density, charge density*, or *charge per square centimetre*.

The Electric Field as a Field of Force

The form and scope of an electric field is determined mathematically. The "maps" of electric and magnetic fields found in "popular" text books are often endowed with a physical reality which they do not possess. Neither do "maps" obtained experimentally truly reflect the abstract nature of electric and magnetic fields. They often inspire misleading concepts.

Maps obtained experimentally have little value beyond, perhaps, the academic one of verifying the validity of our mathematical methods of assessing the shape and scope of a magnetic or an electric field. There is little or no chance in practice of using experimental artifices to trace out the shape of a field. We are compelled to rely on mathematical formulae and logical deductions which simplify, after a little experience, to a matter of commonsense.

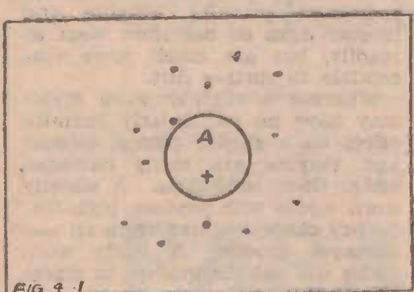


FIG. 1

Point charges surrounding a positively charged body.

Mathematics is an abstract science and mathematicians divest the terms they use of any real significance. Very often the difficulty you may have in following mathematical argument is because, being practical, you endow theorems, definitions, and geometrical figures like circles and triangles with reality when in truth they are only abstract ideas used for the sole purpose of arriving at a conclusion which can be put to some practical use.

Thus, a *line*, in the strict geometrical sense, is an abstraction. In fact, it is a double abstraction because it is the *trace of a moving point*, and *a true geometrical point is a position in space* having no magnitude, and nothing could be more abstract than a position in space without dimensions.

The pencil or ink marks that we may draw with the aid of straight edges, french curves, or compasses are *not* lines as the mathematician thinks of lines. Such pencil or ink marks merely coincide with lines which, *by definition*, can already exist on the surface whereon the marks are made.

The mathematical analysis of an electric or magnetic field is based on two fundamental notions; a *point* which carries *unit positive charge*, and a *line* which is traced out by the point. The line may be either a line of electric force *or* a line of electric induction, its character depending on whether the field is regarded as one of force or induction.

By
A. L. THORRINGTON, A.S.T.C.

A unit positive charge has the same geometrical significance as a point with the additional property of being repelled by positively charged bodies and attracted by negatively charged ones. It should perhaps be pointed out that in some definitions it is unnecessary for the charge to be positive or of unit quantity, but it is more simple to always think of the point charge as being positive and of unit value.

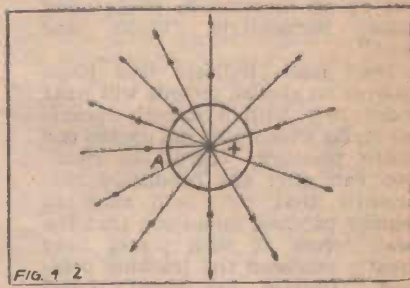


FIG. 2

The various point charges are repelled and move away from the sphere along radial lines.

In a similar way as a geometrical line is a trace of a moving point, so *a line of electric force is defined as the trace or path pursued by a point charge when placed in an electric field*.

Some writers feel it is also necessary to qualify the point charge as being free to move, and they also point out that the introduction of the charge into the field does not modify the latter in any way. One eminent author regards it as a mistake to think of a line of force as the curve described by a positive point charge, because, from his viewpoint, this idea would only be correct if the point charge were entirely devoid of inertia. His modified definition will be expressed later. Your author is of the opinion that such qualifications are superfluous because the only properties that are legitimately possessed by a point charge are those endowed on it by definition so that such qualities as inertia and the ability to modify electric fields are mathematically non-existent.

The Field Intensity Concept

Since, according to Coulomb's law, the force between two charges is dependent on the distance between them, it is clear that the force exerted on our hypothetical point charge, when it is placed in an electric field, will vary as the distance between it and the body establishing the field is varied. It is convenient to think of this varying force at different positions in the field as due to a *variation of electric field intensity*. This idea of field intensity can then be defined as follows:

The field intensity at any point in an electric field is numerically equal to the force in dynes experienced by unit charge when placed at that point.

This definition allows us to use Coulomb's law to express the notion of field intensity mathematically. Thus, to find the field intensity, E at a distance of d centimetres from a charge of Q e.s.u. (electro-static units) of charge, we know that the force, F, in dynes will be,

$$F = \frac{Q \times 1}{K.d^2} \qquad \ldots .4.1$$

so that

$$F = \frac{Q}{K.d^2} \qquad \ldots .4.2$$

The quantity, *one*, appears in equation 4.1 because our test charge is unit value.

But, again by definition, the field intensity E is also equal to the right hand term of equation 4.2, so that we may write,

$$E = \frac{Q}{K.d^2} \qquad \ldots .4.3$$

Equation 4.3 is important, but it is more important that you follow the mental processes involved in its derivation because it is a typical example of the method we use to derive electrical and magnetic formulae. You will shortly see that the concept of field intensity, and equation 4.3, which expresses the idea mathematically, is necessary for the development of the line of force concept.

The Line of Force Concept

If a spherical body A, in Figure 4-1 is charged positively and our hypothetical point charges are placed at various positions around the body they will experience forces of repulsion urging them away from the sphere and they will move along radial paths represented by the lines radiating from the same sphere in Figure 4-2.

These lines, which are the traces of the point charges, are thus, *by definition, lines of electric force.* Since the point charges are positive they will move outward from positively charged bodies and move in towards negatively charged bodies. The arrowheads on the lines of force indicate the direction in which the point charge moves, and gives rise to the idea that an electric field has direction, this direction being defined as the direction in which a free positive charge will move when placed in the field.

It is important to note that when we endow an electric field with directional properties we do not mean that either the field or the lines of force which represent it actually move. Movement is accorded only to the free positive charge.

We have said that point charges placed in a field established by a spherical body will move along radial lines. It is intended to prove this statement, not because anyone is likely to think it untrue but because our method of proving it will illustrate the way in which the shape of fields about more complex systems of charged bodies is calculated, and, simultaneously, confirm an earlier statement that the shape of an electric field can be determined mathematically.

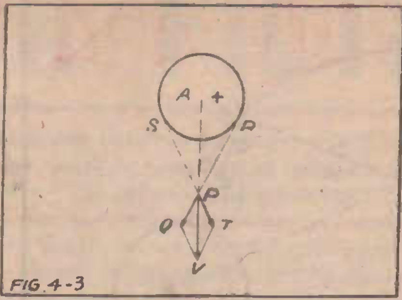


FIG. 4-3

Determining the movement of a point charge.

Positive Charge Forces

In Figure 4-3, A is a positively charged sphere, and near it, at P, is a point positive charge. Let us assume that the forces acting on P are contributed by charges at R and S on the surface of the sphere as shown. Then the force due to R will urge P toward Q, while the force due to S will urge P toward T. If we can recall the *Parallelogram Law of Forces*, we will remember that when two forces act at a point, they interact to produce a *resultant force*, represented in magnitude and direction by the diagonal of a parallelogram, which, in this case, has two sides represented by PQ and PT. Completing the parallelogram, it is clear that the resultant force in this case is PV, and if PV is produced backwards it passes through the centre of A. Hence PV is radial to all spheres having their centre coincident with the centre of A.

We can draw as many lines from the surface of A through P as we wish, so that an infinite number of lines terminate on A, but the resultant of all such lines, which represent electric forces, will still coincide with PV, the first resultant. Also, what is true for P is true for any other point near A. It follows, from the geometrical symmetry of the figure that the positive charge at P must move along a radial line away from A.

Although a mathematician will agree with our final deductions he is hardly likely to agree with our method of getting them. He would require a more rigorous, and, incidentally far more complex, proof than has been given here. But this proof is designed to show you the technique used in attacking these problems; it does not pretend to satisfy mathematicians.

Positive and Negative Charges

The mathematical character of a line of force is better illustrated in the case where there are two charged bodies, A and B, as shown in Figure 4-4. A carries a positive charge; B carries a negative charge. Assume there is a point charge at P. In this position, P is repelled from A with a force Fa, represented by PR, and attracted simultaneously with a force Fb toward B, and shown by PQ. The direction and magnitude of the resultant force on P is represented by PS, so that the point charge will be urged along PS.

However, the instant that the charge moves from P, both the magnitude and direction of the forces Fa and Fb which are acting on it also change, so that the direction in which the charge moves will alter long before it gets to S. Let us assume that the charge has moved to V, where VY and VX are respectively the direction and magnitude of the forces *Fa*, and *Fb*, at the point V. The resultant force at V is then VZ, and VZ differs entirely in direction and magnitude to the resultant force at P.

Now, if we know the magnitude of the charges carried by A and B, we can calculate with Equation 4.3 the magnitude of the forces *Fa* and *Fb* at any point between A and B, and we can then draw parallelograms to scale at each of these points. Finally, if we draw a curve, which is tangential to the diagonals of all our parallelograms, we obtain the path traced out by a positive charge; *we get a line of force.*

Infinite Number of Lines

We can repeat this construction as often as we wish and so get an infinite number of lines. There exists an infinite number of points which do not lie upon one and the same line of force and through each of these points a line of force can be drawn.

For those who cannot imagine a point charge being devoid of inertia and are distressed at the probable effects that such inertia may have on the movement of the charge, we can define lines of force as curves drawn in such a manner that their tangents are at every point in the direction of the vector which represents the resultant forces at these points. Inspection of Figure 4-4 will confirm this.

The Properties of Lines of Force

The so-called properties of a line of force are essentially mathematical properties, in the same way as circles, tangents, and triangles have mathematical properties.

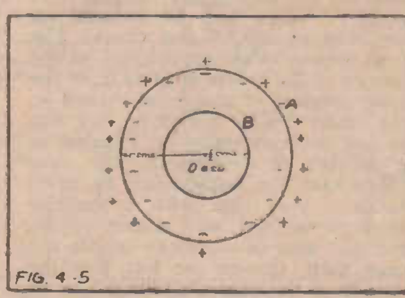
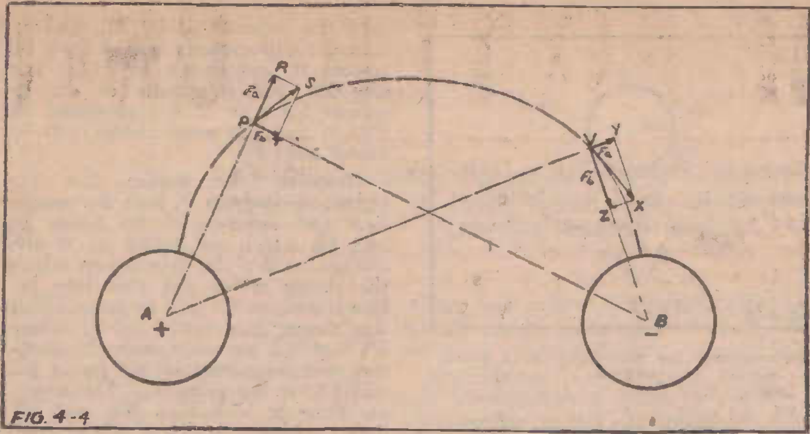


FIG. 4-5

This diagram illustrates the effect of induction.



The method of tracing out the path traversed by a positive charge. The resultant path is referred to as a "line of force."

Thus, a line of force cannot cross another one because this would imply the impossible condition that a free positive charge could move in two directions at once, that is, there would be two resultant forces acting through the same point. It could also imply that two charges could exist at the same point at the same time, which is also impossible.

Lines of force cannot be broken because a fractured line would imply that, at the point of fracture, a free charge would not move, and this would indicate an incredible "gap" in the electric field.

Lines of force repel each other because the point charges which trace them are positive charges and so repel each other.

Lines of force have other properties, but these will be obvious from definitions which we will consider later. We have sufficient proof meantime as to the mathematical nature of a line of force.

The Electric Field as a Field of Induction

You will recall that when we think of an electric field of induction we are thinking of its ability to induce charges in other bodies and the effect it has on the dielectric supporting it.

If a positive charge of Q e.s.u. is surrounded by a metal sphere A as in Figure 4-5, negative charges will be induced on the inner surface, and positive charges will be induced on the outer surface, of the sphere. The *total amount* of charge induced on the surface of the sphere is Q e.s.u. or the *same amount* of charge as existed at the centre. This important fact was proved experimentally by Faraday in a number of experiments, the most spectacular one being when he stood inside a wire cage with a sensitive electro-scope and was unable to detect any sign of electricity within the cage itself, despite the fact that the outside of the cage was charged to an extremely high potential. Placing the sphere around the charge Q at the centre has the effect of driving the charge to the surface of the sphere.

If sphere A has a radius of r cms. its area is $4\pi r^2$ sq. cms. and the *density* of charge on the surface per sq. cm. is thus,

Density of charge per sq. cm.

$$= \frac{Q}{4\pi r^2} \qquad \ldots .4.4$$

Simple Example

If sphere A is replaced with a sphere B having a radius of r/2 cms. the total quantity of charge induced over the surface of B is still Q e.s.u. of charge, but now the *density* of charge is,

Density of charge on B

$$= \frac{Q}{\pi r^2} \qquad \ldots .4.5$$

so that the density of charge on B is four times the density of the charge induced on A. We express this fact mathematically by saying that the *induction* at B is four times the *induction* at A, and we think of this higher induction at B being due to the dielectric surrounding the original charge being electrically strained four times as much at B as it is at A.

This simple example shows that the induction or strain at any point near a charge is *independent* of the dielectric occupying the space around the charge. It shows that the induction at any point depends on the magnitude of the inducing charge and the distance between the charge and the point considered; in fact, the induction varies inversely as the square of the distance between the point and the charge.

To express the idea of induction mathematically we must first define the condition representing *unit induction. Unit induction is defined as the induction one centimetre from a unit charge.*

It follows from the example given and the definition of unit induction that the induction D, at a distance d centimetres from a charge of Q e.s.u. is,

$$D = \frac{Q}{r^2} \qquad \ldots .4.6$$

An electric field considered as a field of induction can be mapped out in the same way as we map out the field as a field of force, only in this case, we accept the lines of induction to mean the direction in which the dielectric supporting the field is electrically strained or deformed. In all ordinary dielectrics that we are likely to find in practice, the direction of electric strain and the direction in which a free positive charge would move are the same so that lines of induction and lines of force coincide.

CONDUCTING FILM ON GLASS

Electrapane, a recent development, is a glass coated with a transparent conducting film of oxide, which makes it possible to carry electric current for de-icing and de-fogging applications in window installations. The thin oxide film, by virtue of its electrical resistance has the ability to heat up quickly and operates on either a-c or d-c voltages. Contact is made by means of thin metal electrodes placed along parallel edges of the glass.

The electrical resistance is substantially constant up to 450 degrees F, above which temperature the resistivity increases gradually. The oxide coating is stated to be practically as durable as the glass itself, and this has been proved by extensive weathering, abrasion, solvent and life tests.

SCRATCH FILTER UNIT

To ensure the best listening quality from any high-fidelity amplifier it is usual to include a scratch filter to exclude any noise caused by record imperfections and wear. Here are details of an American commercial unit, taken from a recent issue of "Radio News," and which should be of interest to all high quality enthusiasts.

With the emphasis nowadays on high fidelity reproduction, most amplifier enthusiasts endeavor to obtain the maximum results from their equipment. However, irrespective of the care taken with the design and construction of an amplifier to achieve the requisite wide frequency response, the final result is often marred by the presence of scratch noise—caused by any slight imperfections in the record as well as the overall roughness which develops as the record becomes worn.

A true high-fidelity amplifier will reproduce the scratch frequencies as well as the recorded music, and whilst this condition may be accepted without objection by some, others find it is highly irritating to the extent that the *"highs"* must be suppressed to reduce the scratch level. This meant that a device was needed to suppress the scratch level when no high frequencies were present, but would quickly *"open up"* and allow the higher frequencies to pass when required.

Although the scratch would also be passed as the device *"opened up,"* it would be *"masked"* to a certain extent by the high frequencies. Such a device would then be an effective scratch eliminator and would allow the critical listener to enjoy high-fidelity reproduction with a minimum of scratch.

The speed at which the scratch eliminator must respond eliminates the possibility of using mechanical means for varying the capacity to shunt the signal and as a result a capacitive reactance tube is usually employed. The rapidity with which the effective capacity of this tube can be varied makes it very suitable for this application.

Schematic Diagram

The schematic circuit for a scratch eliminator of a type now being used in some overseas receivers is shown in Figure 1. Valve types 6AQ6 and 6BA6 are employed. The 6AQ6 is used as an audio amplifier, its diodes being used to develop the bias voltage for the reactive valve. The 6BA6 is connected as a capacitive reactance valve.

An audio signal from the crystal pickup is impressed across the voltage divider network R3 and R4. A part of this signal is coupled to the grid of the audio amplifier by C3. The signal is then amplified and coupled to the output jack through C4 and the tone compensation network composed of R9 and C6.

It may be seen that the circuit thus far outlined is a conventional audio amplifier stage and, with the exception of the tone compensation network in series with the output, no frequency discrimination will be accomplished. To complete the scratch eliminator the following components are added: a feedback network consisting of a 68 mmfd condenser (C2) and a 6.8 megohm resistor (R5) coupled from the output of the audio amplifier back to the input to provide a certain amount of degeneration for the high scratch frequencies; and a 68mmfd condenser (C5) coupling the signal back to the diodes, where it is rectified. Due to the low capacity of C5, only the high frequency signals will be coupled to the diodes since the reactance of C5 will be high for any low frequencies.

The 6AQ6 is self-biased with approximately two volts on its cathode. Since the diode load resistor (R6) returns to ground, this two volt bias acts as a source of delay voltage. Thus, when the frequency is high enough, C5, due to its low reactance, will couple enough signal to the diodes to overcome the delay voltage.

It is also interesting to note that, during low level passages the amplitude is too low to overcome the delay bias and no rectification takes place, even in the presence of high frequency signals. This is normal operation since the passing of the higher frequencies would also allow the scratch to be passed. Since the recorded signal is at a low level, the scratch would actually mask the signal, and the reproduction would be lost in the scratch. This operation would have the effect of an intermittent *"hiss"* and would be very objectionable.

Diode Current

The rectified diode current flows "down" through the diode and resistor (R6) giving a negative polarity at the top. This voltage is then filtered by the RC network R7 and C7. The voltage across the condenser C7 is applied to the grid of the reactance tube and controls the transconductance of the valve. It is well to point out that the charge path for C7 is through the diodes and R7, while its discharge path is through R6 and R7. The resistance of the diodes can be disregarded since it is so low compared to the 3.3 meg resistor (R7). Resistor R6 is equal in value to R7, making the discharge time of C7 twice as long as the charge time.

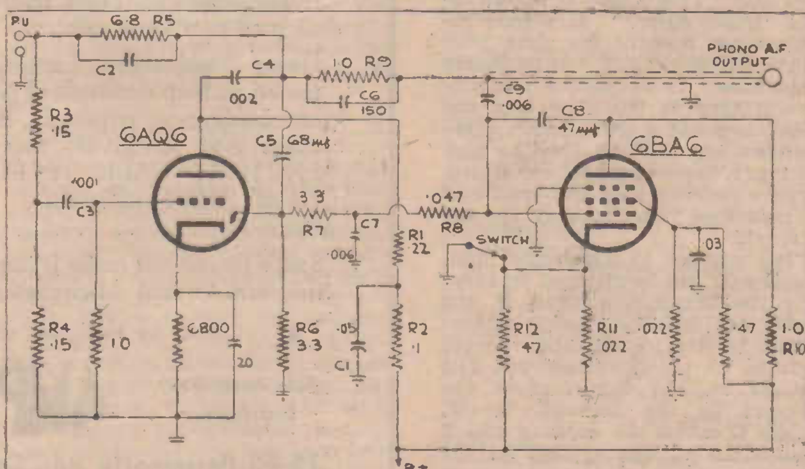


Fig. 1. Complete schematic of the scratch eliminator.

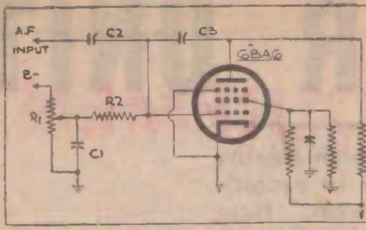


Fig. 2. Diagram of the stage in which the "Miller Effect" is achieved by means of a valve having pure resistance as a plate load.

Although this slower recovery time would seem very objectionable, the discharge path of C7 is found to have a time constant of approximately 0.4 second. This is quite fast and only on badly worn records is there a noticeable hiss following the high frequency notes.

As stated previously, the voltage across the condenser C7 is impressed on the grid of the reactance valve. The audio signal is also coupled to the same grid through the condenser C9. The purpose of the resistor R8 is to isolate the audio signal from C7 which has enough capacity to shunt or attenuate the higher frequencies of the audio signal.

In order to understand the operation of the complete circuit a thorough knowledge of the theory for this particular type reactance tube is required. Therefore a review of this follows.

The Miller Effect

Although the stage used to vary the capacity, which shunts the audio signal, has heretofore been referred to as a capacitive reactance valve, actually the *"Miller Effect"* of a valve having a pure resistance as a plate load is employed. The circuit of such a stage is shown in Figure 2.

The input impedance of a valve having any plate load varies as the transconductance of the valve is changed. This effect is known as the *"Miller Effect."* If a pure resistance is used as the plate load, the input impedance will be purely capacitive. If a reactive component is used as the plate load the input impedance will contain a resistive component. As can be seen in Fig. 1, the resistor R3 constitutes a pure resistive load and results in a capacitive impedance at the input grid.

The manner in which the input impedance can be changed by varying the transconductance of the valve can be more clearly understood by considering the charges existing on the valve elements. The charge on any condenser is expressed by the formula, $Q=CE$, where C equals the capacity and E equals the voltage applied on the opposite plates of the condenser. The charge on the grid of a valve, due to the grid-cathode capacity, may be found by multiplying the signal voltage by the grid-to-cathode capacity. Note that this charge will change according to the amplitude of the input signal, but it is not dependent on the transconductance of the valve.

The charge existing between the grid and plate will vary as the gain of the valve is changed. This can be seen by calculating the output voltage of the plate. The output voltage is found by multiplying the signal voltage by the gain of the valve:

$E_{out} = E_{signal} \times M$, where M equals the gain of the stage. Since we are calculating the voltage between the grid and plate and the grid voltage is 180 degrees out of phase with the plate voltage, the potential difference must be found by the quantity: $E_{signal} \times (M+1)$. Thus the formula for the charge on the grid due to grid-to-plate capacitance is:

$Qgp = E_{sig} \times (M+1) \times Cgp$.

Since the charge on the grid, due to the grid-to-cathode capacity, is not dependent on the gain of the valve it can be added to the effective grid-to-plate capacitance. Then the entire input capacity can be calculated by the formula: $Cin = Cgk + Cgp \times (M+1)$. Although the input capacity will be increased many times due to the *"Miller Effect,"* it is still low due to the low grid to plate capacity of the 6BA6, and in fact, it is much too low to be useful at audio frequencies. Referring again to Fig. 2, it can be seen that a 47 mfdcondenser (C3) has been added between the plate and grid to materially increase the grid-to-plate capacity.

Resistor R1 in Fig. 2 is shown as a variable control so that a varying bias may be applied to the valve. This bias compares to the voltage developed by the current flow in the diodes across R6 in Fig. 1. By varying the setting of resistor R1, the gain of the stage may be controlled. As the arm of the control is advanced, the gain is decreased, and reversing the motion increases the gain.

Let us assume that the arm is moved up enough to apply cut-off bias to the valve. By referring to the formula:—

$Cin = Cgk + Cgp \times (M+1)$.,

we find that the input capacity will be the sum of Cgk and Cgp only since M (gain) equals zero. However, if the arm were set to the

(Continued on page 47)

RADIO FREQUENCY MEASURING EQUIPMENT

By ALAN WALLACE

The cathode ray oscilloscope is an important adjunct to the amateur operators equipment, as it provides a continuous and ready means of checking the modulation as well as the extent of the sidebands. In this article the author briefly covers the operation of the C.R. tube, and describes the construction of a simple oscilloscope.

In view of the mystification still surrounding the operation of the cathode ray oscillograph and associated circuits, it is considered that a brief resume of the fundamentals of its operation will not be amiss, particularly in view of the increasing importance of the C.R.O. for amateur work. Since, at the present time, cathode ray tubes are available at such cheap prices, and the associated circuits are so simple, no worthwhile amateur station should be without the means to conduct continuous modulation checks; at least on its own transmissions, and preferably, should also have the facilities for checking the extent of sidebands, and the production of splatter.

The first requirement may be fulfilled by the construction of a simple oscillograph, as described later in this article, whilst the latter facilities may be obtained by the use of a simple panoramic adaptor as will be described in a later issue of this series.

Original Oscillograph

The original oscillograph, which was the forerunner of the modern cathode ray oscillograph, had no connection with electronics, but consisted merely of a stylus drawn across a moving paper. The trace left by the stylus upon the paper, represents by its shape (since the time rate of displacement is constant), a graph against time of the actuating force on the stylus. This principle is still used in many commercial applications, but a parallel version which most physics students will remember, is the famous Cusson-Atwood machine. This is used for demonstrating the constancy of the force of gravity upon a falling body, although in this case, the rate of movement of the stylus has a constant period and the rate of movement of the paper is continuously increasing.

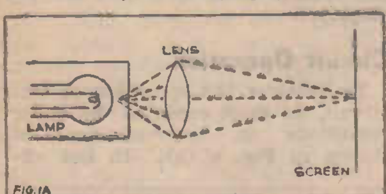


Fig. 1 (a). The operation of the C.R. Tube may be compared to this equivalent optical system.

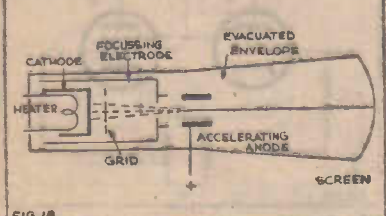


Fig. 1 (b). Basic cathode ray tube.

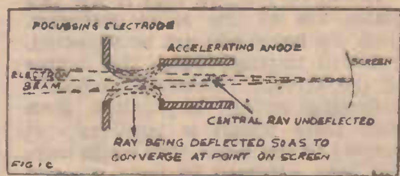


Fig. 1 (c). This diagram illustrates the focusing action on the electron beam.

PART 4
CATHODE RAY OSCILLOSCOPE

"Light-Beam" Unit

An improvement on this fundamental oscillograph is the *"light beam"* oscillograph. In this oscillograph, a small mirror is suspended in such a manner that its displacement, in either vertical or horizontal planes is proportional to the current flowing through the respective deflecting coils. A beam of light trained upon the mirror, is reflected on to a screen or piece of light sensitive paper, in similar fashion to the mirror galvanometer, and the spot produced will produce a trace which is the resultant of the currents flowing through the two coils.

Cathode Ray Tube

The modern instrument of course, uses the piece of apparatus known as the cathode ray tube. In this tube, a stream of electrons is produced by the *"electron gun"* in much the same way as light would be produced from a can containing a lamp, the end of the can being punctured by a small hole, i.e. the stream is emitted largely in a forward direction, but is somewhat diffused. If some means of focusing be employed, such as, in the optical case, by the provision of a lens, the stream will take on the form of a beam which, when correctly adjusted, will produce a small sharply defined spot on the screen.

On the other hand, in the electronic case, there are two means of focusing an electron beam, either an electro-static or electro-magnetic method. As both of these rely upon the inter-action between the focusing field and the field surrounding the electron beam, only one will be described, particularly

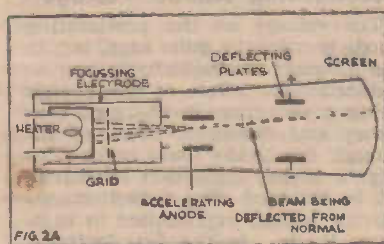


Fig. 2 (a). Basic C.R. Tube with one pair of deflecting plates.

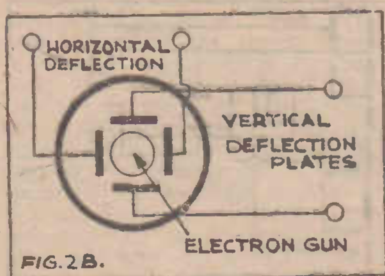


Fig. 2 (b). Arrangement of the four deflecting plates in C.R. Tube.

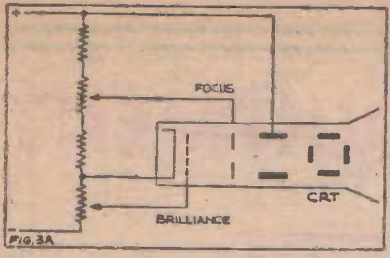


Fig. 3 (a). Divider network to supply C.R.T. with correct potentials.

since electrostatic focussing is the only method used in the smaller tubes at present.

Focusing Action

This focusing action is produced in the electrostatic cathode ray tube by passing the beam through the electrostatic field produced as a result of the difference in potential between the focusing electrode and the accelerating anode. The configuration of this field may be varied by alteration of this difference in potential, and is usually accomplished by variation of the potential of the focus electrode. This focusing action is shown in Fig. 1c.

The purpose of the accelerating anode, apart from assisting in the production of the focusing field is to accelerate the electron beam, imparting sufficient velocity to it to enable the production of a satisfactory spot upon the screen. This screen is usually composed of some substance, such as zinc sulphate which, under the impact of high velocity electrons, "phosphoresces," i.e., it produces a small luminous spot which remains for a short period. the exact length of time depending on the "persistence" of the screen.

Accelerating Anode Voltage

The voltage on the accelerating anode is normally quite high, but, in the interests of simplicity it may be reduced. The effect of this change being a reduction in the spot brilliancy and definition obtained, although due to the lower beam velocity, a higher deflection sensitivity will be obtained. The deflection sensitivity, usually represented in m.m. /v or Kv/in. In the first instance, it is the fraction of a m.m. deflection which can be produced by one volt difference of potential between the opposite deflection plates.

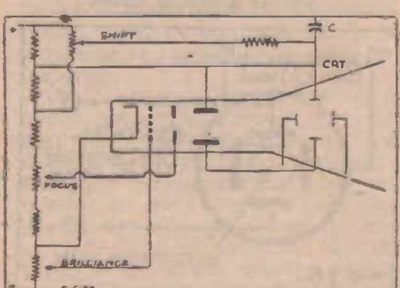


Fig. 3 (b). Application of shift potential to one pair of deflection plates.

Deflecting Beam

In order to produce the deflection of the electron beam in the desired direction, it is necessary to have two sets of deflection plates, mounted symmetrically about the axis of the tube, known respectively as the x and y plates. The effect of these deflection plates is to produce, by attraction and repulsion of the electron beam, the movement of the spot on the screen, and their arrangement is such that the deflection is proportional to the difference in potential between opposite plates.

It will be realised that if the two plates are at the same potential, then the beam will not be deflected, but will impinge upon the centre of the screen. However, should a deflecting voltage be applied, then that plate which is positive with respect to the beam (the beam having been assumed to have reached the potential of the second anode) will exert an attractive force, whilst that plate which is negative with respect to the beam will have a repelling action. It is usual, since the pair of plates situated nearest the electron gun will have the greater effect on the beam, and hence the greater sensitivity, to use these plates for the Y, or vertical deflection. In most cases the amplitude of the voltages applied to the Y plates is usually sufficient to require less sensitivity.

Two Systems Listed

Two systems of applying the deflection voltages may be employed, depending on the results desired, and the degree of simplicity necessary. The simpler method and that which is compelled when using the smaller CRT's (by virtue of their internal wiring), is to connect one of each pair of deflection plates back to the accelerating anode of the tube and apply the deflection voltage only to one plate of each pair.

Whilst this system is quite satisfactory with a small tube, when the limits of deflection are not large, its use with a larger tube gives rise to several undesirable effects. The main effects are defocusing of the beam at extremes of deflection, trapezium distortion and astigmatism (all of which are the result of the distorted field surrounding the deflection plates and second anode), and also a loss of deflection sensitivity, as compared with that obtained when using push-pull deflection.

It is necessary, or at least very desirable, to have some means of varying the rest position of the spot, as this determines the position of

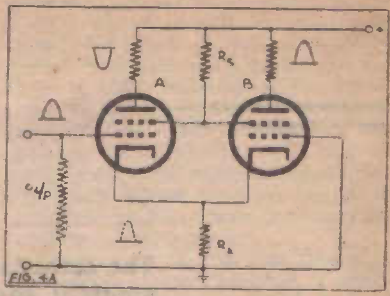


Fig. 4 (a). Cathode coupled push-pull stage.

the trace on the screen. This, in addition to permitting centring of the trace to counteract the effect of any asymmetry in the electrode assembly, allows the trace to be shifted so as to examine in detail any particular portion, such as waveform peaks. Any means adopted to vary the rest potential of one plate, with respect to its opposite will produce this effect, and the particular method employed will depend on whether single ended or push-pull deflection is used.

Push-pull Deflection

If single ended deflection is used, then the simplest method of providing the shift voltage is to return one plate, through a high resistance so as not to lower the input impedance of the tube, to a source of voltage which may be varied above or below the potential of the second anode. This system is shown in Fig. 3 (b).

In the case of an oscillograph where it is desired to use push-pull deflections, it is possible to employ a very simple means of obtaining the required push-pull voltage; and at the same time develop a shift potential which may be varied quite easily, producing an instantaneous shift as compared with the time lag, due to the charging and discharging of C, which exists when the system used in Fig. 3 (b) is employed.

Circuit Operation

To consider the operation of this circuit, we must examine the static conditions in the arrangement shown in Fig. 4 (a). In the ab-

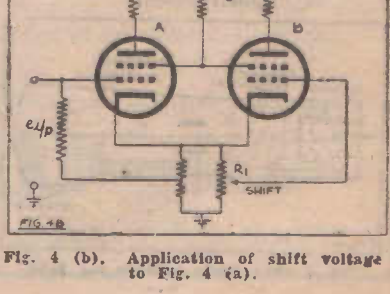


Fig. 4 (b). Application of shift voltage to Fig. 4 (a).

sence of an input signal, the grids of valves A and B will be at the same potential, and therefore so will be the potentials of their plates and screens. The operating condition is for class A, determined by the size of the bias resistor RK, which, of course, will be one-half of the usual value required for a single tube.

Now assume that a signal is applied to the grid of valve A such as to drive its grid in a positive direction. This will cause an increase in ia, resulting in a corresponding fall in ea at the plate of valve A, as shown. Simultaneously, this rise in ia will tend to cause the voltage drop across Rk to increase, thus increasing the bias on valve B, the grid-cathode voltage of which is determined solely erk. This increase in bias causes a fall in ia of valve B, and hence its ea will rise by a corresponding amount, and thus it will be seen that from the single input voltage applied to the grid of valve A, we have obtained two simplified voltages, 180° out of phase from the anodes of the two tubes.

Screen Grid Action

The action of the screen grids, owing to the coupling effect of the unbypassed screen resistor, Rs, is similar to that of the cathode voltage. In the case of pentode tubes, connected as shown, the degree of unbalance may be reduced to less than 2 per cent., whilst the total gain of the stage (el/p—ep-p) is the equivalent of that which would be obtained from a single-ended, adequately by-passed stage.

It will be seen that, at the expense of an additional tube, we have obtained a push-pull stage exhibiting almost ideal characteristics for an oscillograph amplifier in that there are no bypass condensers to cause frequency discrimination. By the use of a "floating" CRT power supply, direct connection may be made between the amplifier anodes and the CRT deflection plates. This allows instantaneous spot positioning, as will now be seen, as well as obviating the need for coupling condensers which may again cause undesirable frequency discrimination.

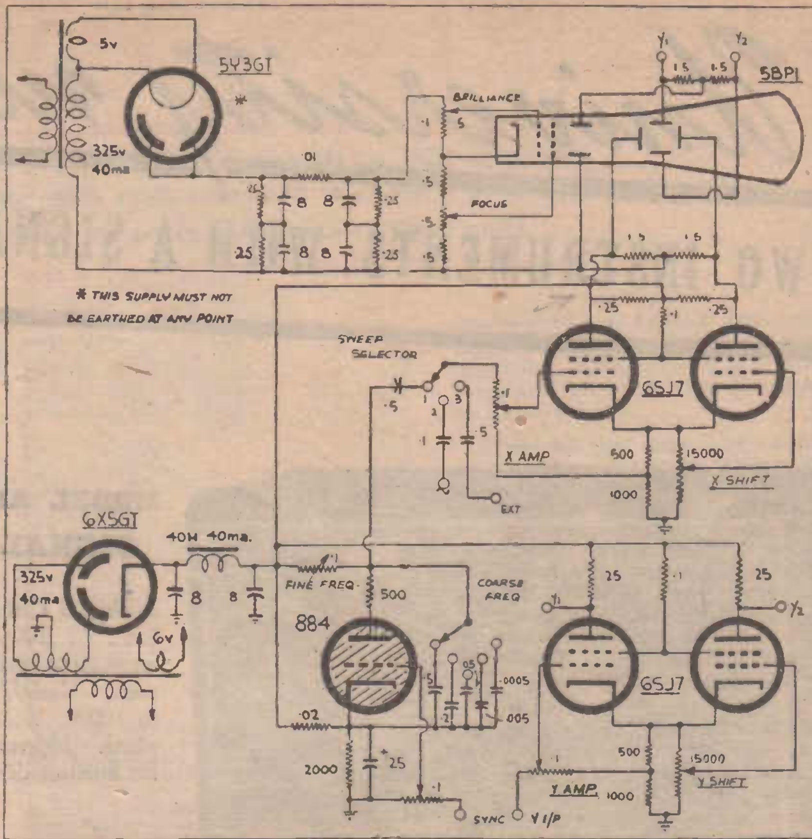


Fig. 5. Complete schematic diagram of the simple monitoring oscillograph. If desired the 6SJ7 can be replaced by a single 6SL7 or 6SN7, by omitting the screen resistor and reducing plate load to .05 meg.

Shift Voltage Development

To follow the mechanism of the development of the shift voltage, consider Fig. 4 (b). In this case, if R should be set so that the potentials applied to each grid are equal, then the respective plate potentials will be equal and the mean position of the spot will be central, assuming direct connection to the CRT plates.

However, if, say, the position of R is such that the bias applied to the grid of valve B is greater than that applied to valve A, then the ea of valve B will be higher than that of valve A, and the mean position of the spot will be to one side of the centre. Conversely, if the bias on valve B is less than that on Valve A, the mean position of the spot will be to the other side of centre. Since there are no condensers in the circuit requiring an alteration of charge, this positioning control will be instantaneous.

A final factor which must be considered when providing the deflection arrangements for a CRT, is to arrange that the mean potential of the deflection plates approximates that of the second anode. Should this condition not be fulfilled, then astigmatism will be experienced, and it will be found impossible to obtain a satisfactory focusing action.

Complete Circuit

All of these features have been combined in the complete circuit diagram as shown in Fig. 5. The only section of the circuit which has not been dealt with is the timebase, which, however, is of quite conventional form. In the particular arrangement shown, extreme simplicity and economy are the keynotes of design, but notwithstanding, the desirable features of a 5in. presentation and push-pull deflection are retained. There is no reason why any individual constructor, who considers himself competent to do so, should not add

(Continued on page 44)

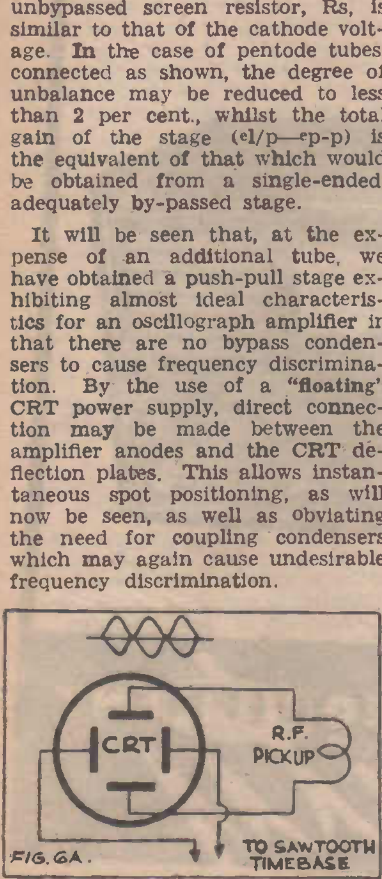


Fig. 6 (a). The circuit to obtain modulation envelope.

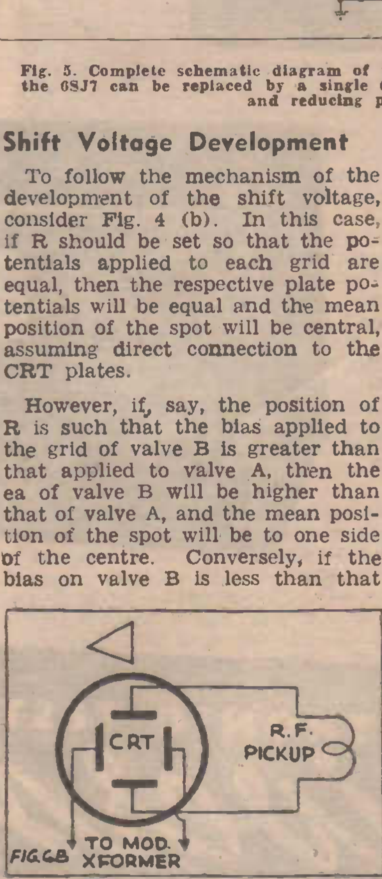


Fig. 6 (b). The circuit to obtain trapezoid pattern.

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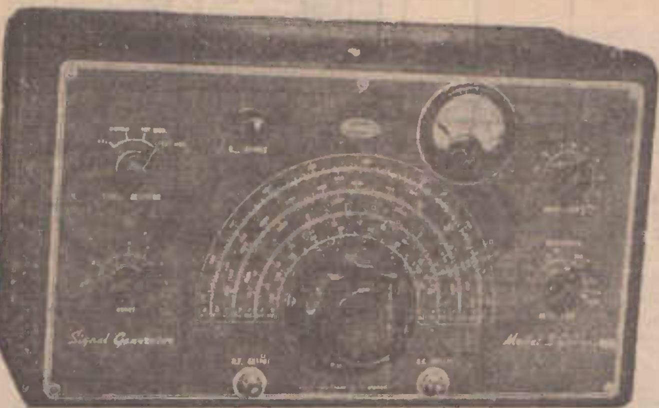

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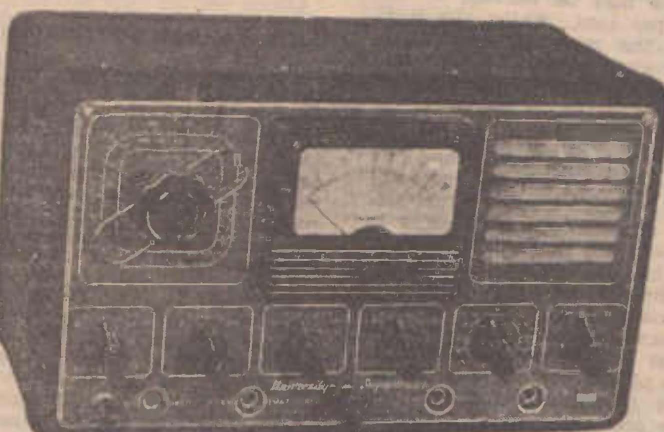

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DYNAMOTOR DESIGN

Dynamotors are widely used in aircraft as well as certain types of mobile radio equipment, and this article deals with some of the factors in the design of these units.

A dynamotor, which is a combination motor and generator wound on a single iron stack, differs from a motor generator because it has only the common iron system, while a motor generator has separate iron circuits. Because of the common use of the iron by both the input and output, the action of a dynamotor is different from that of a motor generator.

The output voltage, which cannot be regulated by changing the field excitation, could be expressed as follows:—

$$E_{output} = \left\{ E_{in} - I_{n} R \frac{T_{out}}{T_{in}} \right\} - I_{out} R_{out}$$

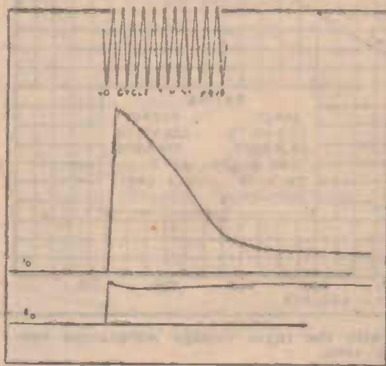
That is: The output voltage is equal to the input voltage minus the voltage drop in the input circuit (which is the voltage directly applied at the input commutator) times the turns ratio of output to input, minus the voltage drop in the output circuit. If the previous formula were analysed, it would be noted that neither the speed nor field excitation nor flux appear in it.

This is perfectly true, and it is one of the major features in the use of a dynamotor. When the input voltage varies, as it will on a battery or generator circuit, the output voltage changes by the same percentage. Inasmuch as the turns ratio is fixed once a unit is wound, there is no way of changing this ratio for purposes of controlling the output voltage.

Wattage Output

Wattage output will be the governing factor in deciding the size of a unit. To maintain a normal temperature rise, the unit must be of sufficient size to dissipate the heat generated from the loss wattage of the unit. For instance, a 20-watt output dynamotor with 50 per cent. efficiency would have to dissipate approximately 20 watts of heat, while a 200-watt unit with 60 per cent. efficiency would have to dissipate approximately 130 watts of heat. (For a general illustration, it is assumed that all the losses are converted to heat).

The heat dissipation is handled in two ways. The first is to have



Observed running data on a dynamotor with a starting amp. of 108 and a starting time of .232 seconds. In this plot EA.=24.2; IA=15.5; EB=5.36; IB=.450.

a totally enclosed unit and to depend on the transfer of heat from the external surfaces. This unit will be the larger of the two classes. In the second method an integral fan is attached to the unit to draw air through it and thus cool it more effectively. By using a fan, the rating of a unit can be raised approximately two and a half times over the totally enclosed rating.

The heat losses may not be the limiting factor for a given wattage output. As wattage is made up of both voltage and current, an excessively high voltage with a small current may require a larger unit for the same wattage output, because the high voltage in the armature will require more room for extra insulation, and also creepage paths must be longer for external circuits. These extra precautions increase the size of a unit.

Input voltage also affects the size of a unit. For the same wattage output a 6-volt input unit will be larger than a 26-volt input unit. This is due to the fact that the current for the 6-volt unit is considerably higher than that for the 26-volt input. That means larger wire, bigger commutators and brushes.

Brush Size Important

The size of the dynamotor brushes is very important. The temperature of the commutator depends largely on the current density in the brushes. If the current density in the brushes is high, bad commutation will result, which will cause short life of both brushes and commutators. The grade of the brush must also be proper for the value of input voltage.

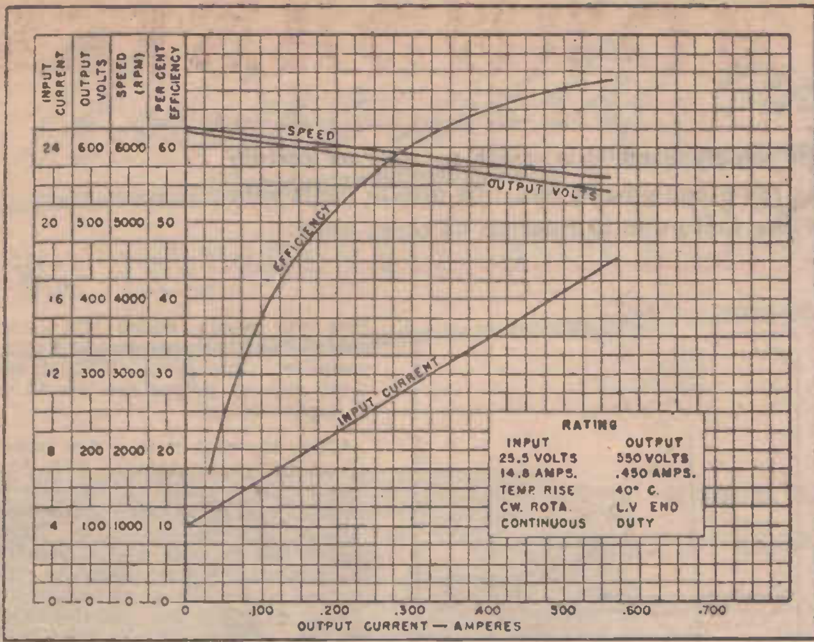
When the unit runs, a film builds up on the commutators. This film varies for different grades of brushes, and each grade produces a film of different resistance. From this it will be seen that the grade of brush on the A side plays an important part in determining the voltage of the B side. If the input voltage is low, the brush must have low specific resistance and have a film of low resistance, or the voltage drop through the brushes and film would be too high a percentage of the input voltage.

Ripple Effect

One of the more elusive factors to be considered in designing a dynamotor is that of ripple. In producing d-c by means of a dynamotor what one gets is not strictly d-c, but rectified a-c. In the rectifying, the resultant voltages vary by as much as 1 per cent. from the actual direct current value. In other words 99 per cent. would be d-c and 1 per cent. would be variable d-c. This is variable d-c, because the amplitude changes, but the polarity does not.

The normal way to measure the variable d-c voltage is to place a 2-mfd capacitor in series with a rectifier voltmeter and place these directly across the output. The capacitor blocks out the d-c voltage, but passes the variable component, which is read on the voltmeter. Brushes for a specific unit are chosen or discarded on their ability to commutate with a minimum of ripple. Anything that will affect the steady output of d-c will affect the ripple value.

It is well-known that silicon iron has a different permeability in the direction of the grain than it has at right angles to it. If the laminations in the armature were stacked so that the grain was all in the same direction, the permeability of the complete armature would change as it revolved through 360 deg. This would cause the flux that flows through the armature to fluctuate



Performance characteristics of a dynamotor with the input voltage maintained constant at 25.5 volts.

and increase the variable part of the d-c output, which is known as ripple. In the early stages of development, it was thought necessary to rotate each lamination from the next one by one tooth, so that a uniform flux path would occur. Later investigation proved this unnecessary if the punchings are scrambled and random stacked.

In the normal motor or generator, the armature slots usually run straight and parallel with the shaft. In the dynamotor, to smooth out the abrupt change from minimum to maximum flux, the slots are skewed in a spiral so that the change is more uniform and gradual.

Accurate Windings Necessary

In the windings, it is very necessary that all coils have exactly the same number of turns. Most output coils are wound separately in forms and then inserted in the armature. In winding these coils, it is possible to vary by one or two turns, unless great care is observed or an automatic winding machine used. The variations of turns from coil to coil increases the ripple.

After the windings are in the slots, the coils must be connected to the proper bars, so that when the brushes pick up the voltage the coil sides will be in a neutral zone. If the lineup is not held very closely, the ripple will be high.

The surface of the commutator has an important function in keeping the ripple down. It should be free from burrs, scratches, and anything that might cause a brush to chatter. Some claim that the surface should be smooth as a mirror, and others that a very fine microscopic thread should be turned on the surface. Both methods have their good and bad points. Needless to say, the brushes must ride smoothly and steady to provide arcless commutation and produce good ripple characteristics.

The ripple must, of course, be filtered out for quiet operation of equipment used with the dynamotor.

Background "Hash"

In electronic apparatus, background hash is hard to overcome. Some of this hash is generated in the dynamotor and is picked up by the electronic system both as conducted and radiated noise. During investigations to attempt to reduce this value, it was discovered that the physical position of the input and output windings in the armature had an important bearing on the amount of hash generated.

Originally, the high voltage winding was wound in the armature first and then the motor winding was wound on top. With this method, it is possible to machine wind the motor winding and thus reduce the cost of the unit. However, the noise is considerably reduced by putting the motor winding on the bottom and the output winding on top. This is a more expensive way of winding an armature, but the better performance justifies the added cost. An additional method for reducing the hash is the addition of small bypass capacitors across the commutators and brushes.

Duty Cycle

The next consideration is duty. Units are classed as intermittent or continuous. Continuous duty machines are always larger than intermittent duty ones for the same output watts. Temperature rise is the factor that governs the size of the dynamotor.

There are innumerable cycles for intermittent duty units. For instance, one cycle could be one minute on and three minutes off. That is a 25 per cent. duty cycle. Classing a duty cycle in per cent. could be very misleading. A cycle of fifteen minutes on and forty-five minutes off is still a 25 per cent. cycle. However, a unit that could stand one minute on might not be able to stand fifteen minutes continuously.

There is another factor in the duty line to be considered, and that is the type of operation, or how often a unit is started and stopped. In some applications, a unit is started and runs for a long period of time before it is shut down. Another may start and stop very frequently. Special care must be exercised on units that start and stop many times.

Determining Regulation

One of the main operating characteristics is that of regulation. This is expressed in percentage and is found by subtracting the full-load voltage from the no-load voltage and dividing by the full-load voltage with the answer multiplied by one hundred:

$$Reg = \left\{ \frac{E\ \text{full load}}{E\ \text{no load} - E\ \text{full load}} \right\} \times 100$$

When these measurements are made, the same input voltage must be maintained. The normal regulation for a dynamotor is in the neighborhood of 17 per cent. To get good regulation, it is necessary to use large enough wire in the armature so that the IR drop for both the A and B winding is low. If this drop is low, then the difference between the no-load voltage and the full-load voltage would also be low, and good regulation would automatically follow. If a unit requires some special output value such as a high voltage, a small wire size must be used. The regulation would then be high. These factors are all interrelated and must all be considered when deciding on the proper unit for any particular application.

(Continued on page 44)

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Polish East Prussia

Zone 16—Eastern Zone of Europe:—
European portions of U.S.S.R. including European portion of Soviet Russia, White Russia or Belorussia, Ukraine, and Novaya Zemlya UA, UB, UC

Zone 17—Western Siberian Zone of Asia:—
Asiatic U.S.S.R. UA
Ural
Tadzhik
Kirghiz
Turkomen
Uzbek
Kara Kalpak
Kazak

Zone 18—Central Siberian Zone of Asia:—
Buryat Mongol UA
Oyrat
Siberian Krai (Eastern and Western).

Zone 19—Eastern Siberian Zone of Asia:—
Yakutsk UA
Far Eastern Area or Dalnevostchnyi.

Zone 20—Balkan, Asia Minor Zone:—
Rumania YR
Bulgaria LZ
Greece SV
Crete SV
Aegean Islands SV
Syria AR
Palestine ZC6
Transjordania ZC1
Cyprus ZC4

Zone 21—South-western Zone of Asia, Saudi Arabia:—
Saudi Arabia (Hedjaz, Nejd) HZ
Yemen
Oman
Aden VS9
Asir
Iraq (Mesopotamia) YI
Afghanistan YA
Persia EP
India (Baluchistan only) VU
U.S.S.R. (Transcaucasia only, Georgie, Armenia, Azerbaijan) Kuweit UA
Behrein Island VS8

Zone 22—Southern Zone of Asia:—
India (except Baluchistan and Burma) VU
Assam
Sikkim
Ceylon VS7
Nepal
Mahe
Maldive Islands VS9
Laccadice Islands VS9
Karikal
Bhutan
Pondicherry
Goa CR8

Zone 23—Central Zone of Asia:—
Chinese Republic following portions only C (XU)
Tibet AC
Sinkiang (Chinese Turkestan), Tannu Tuwa (Tannou Touva)
China Proper (Kansu Province only).
Outer Mongolia
Inner Mongolia (Except Chahar Province).

Zone 24—Eastern Zone of Asia:—.
China Proper (Except Kansu Province) C (XU)
Inner Mongolia (Chahar Province only)
Manchukuo (Manchuria) MX
Kwangshow
Macao CR9
Hong Kong VS6
Darien
Japan (Taiwan or Formosa only) J9

Zone 25—Japanese Zone of Asia:—
Japan (except Taiwan or Formosa) J
Chosen (Korea) J8

Zone 26—South-eastern Zone of Asia:—
Burma XZ
Siam HS
French Indo-China FI
Andaman Islands Vu

Zone 27—Philippine Zone.—
Philippine Archipelago KA
Guam KG6
Yap
Caroline Islands
Mariana Islands KB6
Islands east of Philippines, west of Long. 163 deg. E., north of Lt. 2 deg., N., and south of the line from 153 deg. E., 40 deg. N. to 131 deg. E., 23 deg. N.

Zone 28—Malayan Zone of Asia:—
Malay States (Federated and Non-Federated) VS2
Johore
Straits Settlements VS1
Malay Archipelago, including Netherlands-Indies (Dutch East Indies).
Java PK
Sumatra PK4
British North Borneo VS4
Sarawak VS5
Papua VK4
New Guinea VK9
Borneo PK5
Solomon Islands VR4
Timor Islands CR10
Portuguese East Indies CR8
Islands between Lat. 2 deg. N. and 11 deg. S., and West of Long. 163 deg. E.

Zone 29—Western Zone of Australia:—
Australia VK
Western Australia VK6
North Australia
Central Australia

(Continued on Page 46)

Amateur NEWS and VIEWS

Conducted by KEN FINNEY, VK2AIL.

SPOT NEWS

- VK2AOX—Harry Cox has been doing excellent work and can be heard regularly on 20 metres but has only worked VK's so far. His rig is VFO controlled, 6F6 Doubler, 807 final running about 25 watts. Mostly on phone, but has new RX under construction.
- VK2ANW—Jim Cotton is another newcomer to the bands. Is doing good work and seems very ambitious. His present rig is Clapp VFO, 6V6 Doubler, 807 final. Worked VK2's, 3's and 5's on 40 metres.
- VK2WV—Reg Waters has been experimenting with cathode modulation and is now building up a new rig.
- VK2UK—Grev Denny has lost a lot of sleep lately but not with DX. Has been playing around with a disc recording outfit with fair success, but thinks there must be an easier way of doing it. Is now preparing to build his rig into a rack and panel job with the emphasis on 10 and 20 and a beam to follow.
- VK2VH—Alan Ward is now on two weeks holiday at Hawkesbury busily raking them in with a fishing line. Spent the first two days and nights DXing.
- VK2ON—Doctor Douglas can often be heard on the air from his new location.
- VK2WP—Bill Potter has his rig in pieces and intends building it up a la rack and panel. Is now waiting to see the layout of the new rig being built for the club.
- VK2AMD—Howard Booth has been chasing up the G's. Being ex G2AS I wonder if he's getting homesick.
- VK2AMM—Still doing good work with overseas contacts. Two more members have gone for tickets and waiting results. A new transmitter has been built by Eric Fisher Jun. and Senr., and hope to have it working at 2AMW Club Rooms in the near future. Refreshments served after meetings is one of the New Year's moves which is becoming very popular with members.
- VK2ABA—has gone off to Victoria for some time and will shortly be heard as a VK3.
- VK2IY—Tom Cahill, on the 50Mc band with some interesting QSO's. Building receiver for 72Mc when not active on ham bands.
- VK2HT—Malcom Robinson has been looking for the 20 metre band and just found it.

CLUB NOTES

HURSTVILLE DISTRICT AMATEUR RADIO CLUB

C.W.A. Rooms, 378 Forest Road, Hurstville.

Activity at this club has been rather quiet to date this year. On the 18th January, an interesting talk on Amateur Radio in Britain was given by Cecil Bennett, VK-2AKZ, ex G3CPE, a member of the R.S.G.B. Of particular interest was the organisation of field days by the R.S.G.B. to encourage competitive spirit between clubs.

Visitors and any new members are always welcome and the club meets on the 1st, 3rd and 4th Tuesdays of each month at the above address.

WOLLONGONG AMATEUR RADIO CLUB (VK2AMW)

21 Bourke Street, Wollongong

Club activities are in full swing and main project at the moment is to institute an Emergency Radio Unit similar to that described in the January issue of Radio Science. In this respect the Club has been promised the full support of the City of Greater Wollongong Council.

For the benefit of new members and any visitors, the club meets every Friday for technical discussions and lectures whilst the clubroom is open to members every night and at the weekends.

- VK2AHZ—"Mayor of Church Point"—quite active and heard regularly. Stays up late at night with night cap and candle.
- VK2AJB—Les Turner, heard regularly on 40 metres in early hours, with a good signal. Will be in Sydney for the next WIA meeting.
- VK2AGH—Graham Hall, well known on the DX bands recently returning from a business trip to the U.S.A. and England. Receiver being used is a "Super Pro."
- VK2CZ—Ron Petrich of Woy Woy, not very active, but when on the air runs 6 watts on 40 metres CW. The receiver is an AR7.
- VK2YK—Charlie Coyle, is building a very elaborate VTVM. This should be the envy of all the local lads.
- VK2FT—pushing 45 watts into a 6L6 Apart from scorching wall of the shack behind the transmitter, no obvious damage results.

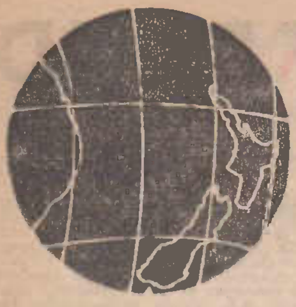
GEELONG AMATEUR RADIO CLUB

65 Malop Street, Geelong

Members of the Geelong Amateur Radio Club have once again commenced holding meetings at their Club Rooms. At the first meeting Mr. Forster brought along a VHF transmitter which interested all members, whilst at the next meeting Mr. D. Heighway, VK3ABK presented an interesting lecture on Radio and AC Frequencies.

The President of the Club, Mr. Alex Bell, VK3ABE, welcomed Mr. Bill Kinsella, VK3AKW; Jack Clay, VK3AJC; John McConnell, VK3SW, who were visitors to the club at the last meeting. Mr. A. Forster, VK3AJF, gave members an interesting evening by describing the various types of Transceivers used by the Army. This talk was well illustrated by many diagrams and proved popular with all.

New members are welcome, and any intending members are asked to get in touch with the Secretary, Bob Wookey, VK3IC, 158 Kilgour St., South Geelong.



TRANS-TASMAN DIARY

By J. F. FOX

(Special N.Z. Correspondent)

A DECADE OF BROADCASTING

The second station of the New Zealand Broadcasting Service to celebrate its tenth birthday within the last few months was the Hawkes Bay Station, 2YZ, formerly 2YH.

On November 17 last station 2YZ completed a decade of broadcasting with full radio honors, and a special programme was presented during the evening transmission.

The history of 2YZ dates back to early in 1938 when the National Broadcasting Service planned a station for the East Coast districts of the North Island. Field tests were carried out in areas around Napier, and eventually it was decided that the most suitable location for the transmitter site was at Opapa, 28 miles south of Napier on the main road to Wellington.

In those pre-war days when the word "shortage" was hardly heard, the construction of a building for the 2 kW A.W.A. transmitter and houses for technicians did not take long to erect. The two new 300-feet steel towers supporting the folded half-wave antenna system soon grew to become a familiar landmark. Meanwhile, in Napier the first floor of Dalgety's Buildings in Dickens Street was being transformed into a modern radio station with two studios, an announcer's studio, control room, workshop, library, offices and lounge.

On the Air

Like any other station entering the broadcasting field, the period prior to the opening is a busy one for a new staff, and this was no exception to the members of 2YH, as it was then called. Comprehensive transmitter tests, technical adjustments to the control room equipment, building the record library and arranging programmes were just a few of the last-minute tasks that were required to be done.

Then on November 17, 1938, the Hawkes Bay station took the air, and the people of the East Coast had their own radio station. The station was officially opened by the Hon. F. Jones in the absence of the Minister of Broadcasting, the Rt. Hon. M. J. Savage.

2YH had not been on the air a year when war was declared, and the plans for the station expansion were brought to a sudden halt. During the daytime the station relayed 2YA, Wellington, commencing its own programme at 5 p.m. When the war spread to the Pacific, members of the small staff of nine began entering the Armed Forces and those left had a difficult task set for them. So acute did the position become that at the end of the war there were no announcers—all the necessary announcements being made by the technicians.

Post-War Expansion

With the war over and members of the Forces returning to the station, 2YH began to take up expansion plans that had been shelved in 1939. The staff was increased to 23, the library built up from 5000 to 22,000 records, and the transmitting period extended to 15½ hours each day.

By 1946 outside broadcasts were introduced to cover football, cricket, races, boxing and wrestling from nearby Hastings as well as Napier. In addition to the local talent often heard from Napier famous artists as Oscar Natzke, Gladys Ripley, Isobel Baillie, Richard Farrell, the Queensland String Quartette, and the Musica Viva Society Quintette of Sydney have broadcast over the 2YZ microphone.

An interesting item in connection with the programmes of the early days was when the staff decided to open a request session. Rather doubtful as to how it would take on, the staff thought that if insufficient requests were received they would include some of their own. The first mail brought 100 letters, within a few days thousands arrived—it took 2½ years to play that batch of requests in the "Listeners' Own"—a regular Monday night feature.

The coverage of the station was originally designed for Hawkes Bay, but from reports which are constantly received the station is heard successfully in all parts of the Dominion. North American radio magazines have often reported that 2YZ is heard in their area.

Anniversary Programme

A historical survey of the station's activities over the last ten years was presented in Cavalcade of Broadcasting which opened the special anniversary programme. Speeches were given by the Minister in Charge of Broadcasting, Hon. F. Jones, Professor J. Shelley, Mr. A. E. Armstrong, member of Parliament for Napier, and the Mayors of Napier and Hastings. Mr. R. D. Brown (Mayor of Hastings) paid a tribute to the early broadcasting station in Hawkes Bay which was transmitting at Wairoa before 2YH commenced operating. The "New Look" in broadcasting was a studio presentation by members of the staff giving listeners a general picture of the working of a broadcasting station.

The Control Room of the Hawkes Bay Station of the N.Z.B.S.

(Photo courtesy of 2YZ).

New Zealand readers are invited to contribute any items concerning radio, broadcasting, DX-ing and amateur radio activities for inclusion in this section. All letters should be forwarded direct to: Mr. J. F. FOX, 41 Bird Street, St. Kilda, Dunedin, S.2. N.Z.

New Type of Broadcasting

A new feature in broadcasting for New Zealand was introduced on January 18, when station 3XC, Timaru, commenced regular transmission. Transmitting each day for seven hours, the programmes consisted of non-advertising and advertising periods—a practice previously not permitted in New Zealand.

Following the opening of 3XC, the next station which is likely to take the air will be 2XA, Wanganui. This station will broadcast the same type of programmes, and observe the same transmission hours as the Timaru outlet. Work is now being carried out by the Ministry of Works Department in the erection of a 175-foot self-supporting radio mast on the car park at the rear of Garrison Hall. Tenders have been called for the renovating of Earl's Buildings into a modern radio station.

General approval of the type of programmes to be broadcast has been expressed by business firms, musical groups and listeners of both cities.

ON THE BROADCAST BAND

NEW A.B.C. STATIONS

Details of the recently-opened A.B.C. regional station, 5AL, Alice Springs, should be of interest to all DX-ers.

The recent installation of the new low-powered regional relay station at Alice Springs has satisfied a long-felt need in its immediate district. It is undoubtedly of particular interest to DXers throughout Australasia, as it is the first regular broadcasting station to operate from Central Australia as well as being the first station in this country to operate on the newly opened 1500 and 1600 kc. band.

This new station uses the call sign 5AL, operates on a frequency of 1530 kc. with a power of 500 watts (according to an ABC report). Although it may spoil the reception for some of us of certain American stations such as KFBX and WCKY, this is more than offset by the novelty of having a new station to log.

Relays Adelaide

The main objective of the new station is to provide listeners in Alice Springs and its immediate surrounding districts with clear reception of the ABC programmes, which previously could only be received through 5CK and other stations operating long distances from the centre. The programme schedule set down is much the same as that followed by 5CK and 2NB, and incidentally 5DR, Darwin.

This will be primarily relays from Adelaide stations 5AN and 5CL, and consequently will feature many sessions familiar to listeners throughout the Commonwealth.

New Taree Outlet

When it took the air on November 15 last, 2TR Taree brought the number of ABC stations on medium wave in N.S.W. to double figures. This station will improve the reception of ABC programmes in the Taree area, and at present employs a power of only 200 watts and is operating on a frequency of 720 kc.

A.B.C. Programmes

With so many ABC stations on the air at present and with large groups carrying the same programme, identification is sometimes difficult. Stations in Capital cities are frequently heard with programmes which are not relayed through their regionals or Nationals in other States, while, and this is important, regional stations have a local news bulletin of 5 minutes' duration week-days at 8 a.m. and again in the evenings at 6.55 p.m.

At present 2NU and 2TR are in chain, but this is only a temporary arrangement. Re the Newcastle station 2NA and 2NC which relay 2FC and 2BL almost continuously, the above bulletins are heard through 2NA.

Operating Schedules

The Main National stations (with "serious" programme) begin week-days at 6 a.m., Sundays 6.45 a.m. and sign off daily at 11 p.m. The Interstate programme ("light" type) opens at 7 a.m. and closes at 11.30 p.m. daily. The regional stations open 6 a.m. weekdays, 6.45 a.m. Sunday and close at 11.30 p.m. nightly.

By
ROY HALLETT

Unusual Verification Cards

The hobby enjoyed by so many DX enthusiasts of collecting verifications of reception of long distance broadcasting stations often provide some interesting surprises. As a result of a report sent recently to the 1kW station at Nagpur, India (VUN3), on 1290 kc., Art Cushon (Invercargill, N.Z.), received a long letter accompanied by a folder card, bearing a photo of the late Gandhi, and another of his home.

The folder was issue as a souvenir of a broadcast recently made from the station (which had been in service since July 16 last) to commemorate the 1st anniversary of the death of this great leader. This station is on till 2.30 a.m. with the usual news in English, heard from most Indians, at 1.30 a.m. Try for this one.

Typical Examples

We have quite a collection of verification "surprises" at our listening post, such as the book of Bible stories sent from KNX Hollywood, as the result of mentioning a particular sponsor, having heard the name of a certain article (a brand of soap), mentioned while copying our report. Although not actually a verification, we received a small telescope sometimes back from station XEAW, so well known to DXers a while back and now KWBU in Corpus Christi, Texas, 1030 kc.

We are also quite proud of the set of picture cards we received from the old XGAP, Peking, China, so one never knows just how "lady luck" will behave after the report has been sent off.

Obtaining Verifications

Verifications by mail are obtained, of course, only after one has proved to the particular station authorities that the programme has definitely been heard. This is usually done by copying down a list of as much as possible up to about 15 minutes period of programme items, listened to, giving time heard, plus details of signal strength of the station as well as any other information of possible interest to the station engineers.

We would be pleased to hear from any readers not experienced in this branch of DX and to send along any further information required.

New N.Z. Policy

New Zealanders experienced something new in local radio services when 3XC Timaru, 1160 kc. 2kw took the air on January 18. This station will now provide listeners with both national programmes, during which no commercial announcements will be broadcast and then periods of transmissions devoted to commercial programmes during which sponsored sessions will be featured, as in the case of National Commercial Broadcasting Service stations.

3XC will operate from 5 to 8 a.m. and again from 4.30 to 8.30 p.m. EST. (Time at the station is two hours ahead of EST), with national type programmes during final three hours of transmission.

With the Listeners

Mr. Ian G. Johnson has written from Manly, Sydney, to tell of his latest doings and has quite a deal to report both concerning loggings and recent verifications. Regarding the latter, Ian is particularly pleased with the letter received from the manager of 3YZ (formerly 3ZR) Greymouth, N.Z. which accompanies the usual NBS verification card.

In this letter Mr. H. O'Loughlin, the manager, says he believes this to be the first report from outside the Dominion to reach the station for some time. Reference was made to the fact that when the station was logged last August, it was on 940 kc. with 100 watts, the call sign being changed to 3YZ on September 1st and the frequency altered to 920 kc.

Mr. O'Loughlin also points out that this small transmitter is located in the main street in Greymouth, a relatively small town with a population of about 9000. The new 10 kw transmitter being designed by Australian engineers, is expected on the air shortly. This has already been heard testing by some New Zealand DXers on 920 kc.

Further reports from other listeners will be appreciated at 3YZ and it should be noted that the station operates continuously from 5 a.m. to 8.30 p.m. EST.

This reader also points out that 1YZ Rotorua, 800 kc. is now having its transmitter installed, and should be on the air before very long. 2XA, Wanganui, 1200 kc. is expected to open with a power of 2kW in April next, and we notice that 1YD (the old 1ZM) is back on 1250 kc.

★ ★ ★

Mr. Ray Rooke, Manly, mentions he is a little disappointed with his reception of "Midnight Americans" this season as compared with his successes last year. However, we might add that he is not the only DXer feeling a little bit that way when comparing present trans-Pacific reception with that of past seasons.

★ ★ ★

Mr. Johnson has been hearing some Midnight Americans at fairly good signal strength—a fact which is causing some speculation in Manly as to the reason for Mr. Rooke's experience of poor reception. KNBC, 680 kc. San Francisco (and this reader must have been among the first to hear them with the new call sign, the former being KPO) at fair level, with KECA, Los Angeles, 790 kc, not quite as strong but coming through after 4QG leaves the air. KNX, 1070 kc. also in Los Angeles, Calif., and KSL, 1160 kc. Salt Lake City, Utah, having been heard, and reports being sent to each of these loggings.

This reader has drawn our attention to some sweeping frequency changes scheduled to take place in Europe, about which we hope to have much to say in the very near future.

★ ★ ★

Mr. J. B. Hargreaves is another to add a few more verifications to his collection in recent weeks. JOAK, Tokyo, 590 kc and Manila P.I., on 920 kc. have sent letters, as has KPOA, Honolulu, Hawaii, 630 kc. The somewhat plain card has also arrived from KGMB in Honolulu, 590 kc. All this and more the result of DX from our friend's residence atop one of our city buildings here in Sydney, seems to us a good effort indeed.

★ ★ ★

A member of the SW League of WA has received a copy of "Pakistan Calling," which refers to four stations operating on behalf of the Pakistan Government. Karachi, is on the air till 3.30 a.m. on 1452, kc, Lahore till the same hour on 1086 kc., Peshawar, 629 kc. till 3.15 with no schedule being shown for Decca, 1167 kc. The last three mentioned are perhaps the best signals from the Pakistan-India area at many locations.

According to announcements being heard on shortwave from Rangoon, their medium wave outlet is operating on 314 metres, or approx. 958 kc, so here is one to watch for during the coming months around 1 a.m.

SHORTWAVE LISTENER

by TED WHITING

CHANGE IN RECEPTION CONDITIONS

Much interesting reception has been reported during the last few weeks, and with the gradual change to winter conditions it will be found that many overseas stations will be heard on new schedules and that new outlets will be placed in service.

It is well known that reception conditions vary from place to place, a few miles in many cases making a great deal of difference to reception. Of recent weeks your writer has been located in the northern part of New South Wales, and although an inferior receiver to that of the home location has been in use, the difference in both reception conditions and the strength of the stations heard has been amazing. Whilst nothing new was heard it was quite an experience to have a complete absence of man-made noises when tuning across the dial.

It is worthy of mention that notice has been given through the Press recently of the intention of the authorities to really do something about this ever-present problem of interference. It will be found that, with the advent of Television, something will have to be done along these lines, and it is to be hoped that this, like so many previous good intentions, will not be allowed to fall by the wayside.

News Flashes

New Zealand Times, organ on the N.Z. Radio DX League is an excellent publication and much of interest can be gleaned from its pages. It is there noted that KZFM Manila, P.I., is operating on 2750kc. and is heard at 10.45 p.m. with a fair signal.

CP15, "Radio el Condor" 5880kc. is another one on the lower frequencies 9.30 p.m.-1.30 p.m. and relays the service radiated by HJER on the broadcast band. Reports are requested by this station they having recently vacated their former frequency of 4865kc. This latter frequency is now used by HJFA.

YV1RG, 6150kc, "Radio Cabinas," Venezoela is to be heard under VLR2, the signals being best heard at 9 p.m. The power used is 800 watts.

Norwegian Schedules

The Norwegian Short Wave Service is now on the air in transmissions to the Norwegian Whaling Fleet some of whom are no doubt in Antarctic waters. The schedule is as follows:

4.30 p.m.-6.30 p.m.: LLK 11850kc LKV 15170kc, LLN 17825kc, LLR 7240kc, LKJ 9540kc.

11 p.m.-Midnight: LLG 9610kc, LLN 17825 kc, LLQ 21730kc, LLR 7240kc, LKG2, 6130kc.

5 a.m.-6 a.m.: LLG 9610kc, LKV 15170 kc, LLK 11850kc.

New Finnish Station

The new Finnish transmitter using 100 Kw is in service on test transmissions between the hours of 6.45 p.m.- 9 p.m., 10.15 p.m.-10.30 p.m. and the transmission is beamed to North America, reports are requested for this transmission on 15190kc, News in English being read at 10.15 p.m., the indentification signal is of 13 notes.

FZI, Brazzaville is now operating slightly higher in frequency and is now on 15620kc to close at 10.45 p.m. after the English broadcast.

Radio Ceylon

The station formerly known as Seac is now heard on its various frequencies announced under its new title of "Radio Ceylon," the announcement being "This is the Forces Broadcasting Service of Radio Ceylon."

READERS' REPORTS

Readers desirous of submitting Short Wave reports for inclusion in these notes, should ensure they reach our Short Wave Correspondent not later than the 1st of each month. Address all letters to:—Mr. Ted Whiting, 16 Louden Street, Five Dock, N.S.W.

Radio Saigon on New Frequency

Radio Saigon is now operating on a new frequency of 7200kc. This transmission is heard after 8 p.m. in relay with the transmission on 11780kc. This transmission is heard after 8 p.m. in relay with the transmissions on 11780kc and 6160 kc. Reports are requested and should be sent to Radio Saigon, 86, Rue de Mac Mahon, Saigon, French Indo China.

Schedules for Moscow

Mr. Hargreaves, Sydney, kindly forwarded to us a letter and cards he has received from Radio Moscow and which contains schedules and two photographs of Moscow streets. The letter is signed by I. Petrov, Listeners' Letter Dept., Box 787, Moscow, USSR and it appears that the authorities are pleased to receive reports.

The schedule is given for the programme for British listeners, the operating times being: Week-days from 5.30 p.m.-5.59 p.m. on 15440kc, 11630kc and 9660kc. On Sunday at midnight to 12.49 a.m. on the same frequencies. Daily at 5 a.m.-5.29 a.m. on 9710kc, 9660kc, 7340kc and 7200 kc, and at 6.30 a.m.-7.28 a.m. on 9660kc, 7340kc and 7200 kc. From Monday to Thursday inclusive at 7.30 a.m.-8.28 a.m. on 9710kc, 9480kc, 7270kc and 6090kc. Daily at 8 a.m.-8.59 a.m., on 9660kc, 7340kc and 7200kc.

Dominican Republic

A new station located in Dominican republic is heard in New Zealand to closing at 6 p.m. on 9525kc; the Call is HI2L. "La Voz del Tropico," power 700 watts. The strong carrier heard on 6080kc at many times is that of W8XAL, Cincinnati, which is running on a 24-hour schedule in research work on propagation conditions, the call being sent in Morse at 4 p.m. at least.

TRY FOR THESE

XUBA, 7220kc, is heard at 9.15 p.m. with western type music and news in Chinese.

XNCR, 9390kc at 10.25 p.m., with the typical service.

XGOA, 7500kc, at 10.30 p.m., a good signal at this time, similar service.

XMTA, 12217kc, with excellent signal at 9 p.m., Eastern service.

XLRA, 11500kc, at 8.30, again an Eastern type service.

XAET, 9500kc, at 9 p.m. with news read by a female.

XGOY, 5985kc, 9730kc and 15170kc is heard during the evenings at most locations all frequencies are productive of good signals. Closes at 1 a.m.

XORA, 11865kc, at 8.30 p.m., signal quite poor at times, Eastern type service.

ZBW3, 9520kc, heard in BBC relay at 9 p.m. Fine signal.

VUD3, 17760kc, VUD8 21510kc, VUD7 15160kc are all heard at fine strength during evening. English news read at 6 p.m.

KUALA LUMPUR, 6030kc is reported at 11.15 p.m. with news, etc.

SINGAPORE, 11850kc is another good signal at 9.15 p.m., BBC relay at this time. This station is a unit of the British Far Eastern Service. Also heard on 6770 kc at 8.30 p.m.

HS8PD on 6000kc at 9.15 p.m. is heard in an English talk at this time.

HCJB, 15110kc is heard well at 9.30 p.m. with religious transmission.

HP5A, 11700kc at 9.30 p.m., also is a good signal here, news in Spanish and Music.

COBC, 9370kc in Spanish service at 8.45 p.m., the slogan of this one is "Radio Progresso."

HH3W, 10130kc in CBS programme at 10.15 p.m., opens at 9.30 p.m. with chimes. Morse is occasionally bad on this frequency.

COKG, 8960kc in Spanish News at 9 p.m., good signal these days.

COCH, 9430kc at 9.45 p.m. with good signal at times. News in Spanish heard from this one also.

VP4RD, 9620kc is still being heard in the very popular session, "Church in the Wildwood."

COBQ, 8820kc, at 10.15 p.m. with news in Spanish, music follows.

TGWA, 9760kc at 4.45 p.m. with a good programme, Spanish news, etc.

TGWA, 15170kc, at 7.30 a.m. with fine guitar music, news in Spanish follows.

XEWW, 9500kc is still one of the best stations. Heard all afternoon till 4 p.m.

KGEI, 9700kc, at 9 p.m. with news and music, at 8.45 p.m. with Melody Round Up.

KGEX, 11730kc at 5 p.m. with news and music.

KWID, 9570kc, 6.30 p.m. with Words and Music Session, news follows.

KRHO, 9530kc, with news round up at 9 p.m., fine signal.

WRUL, 15350kc at 7.30 a.m., transmission of American Bible Society.

WGEO, 15330kc, at 8 a.m. in fine transmission beamed to Europe.

KWID, 17760kc, at 11.30 p.m. with news and music.

WBOS, 15210kc, at 8.30 a.m., again with news and musical programme.

WCBN, 15270kc, a 8.45 a.m. news, commentators' digest, etc.

WNRA, 11770kc, this one at 7.45 a.m., beamed transmission to Europe.

WNRI, 9670kc, at 7.30 a.m., another European service.

RF MEASURING EQUIPMENT

(Continued from page 35)

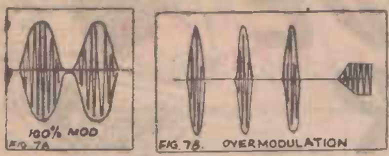


Fig. 7 (a), Pattern for 100% modulation and in (b) effect of overmodulation.

such refinements as a higher-voltage transformer for the CRT H.T. supply, and a charging tube to improve the linearity of the time-base.

Many Uses

This simple oscillograph may be used for many purposes around the workshop, or ham shack, and, as will be seen later, it forms the basis upon which the panoramic adaptor is built. To monitor the modulation characteristics of any transmission, it is only necessary to apply the RF signal to the vertical deflection plates, either directly, or through the vertical amplifier. With the time-base operating (i.e., Sweep Position 1), the resultant trace will be as in Fig. 7 (a), any over-modulation being evidence by breaks in the trace, as at Fig. 7 (b), A trapezium pattern may be obtained, as at Fig. 7 (c) by feeding the modulated RF carrier to the vertical plates of the CRT, whilst the horizontal sweep is derived directly from the output of the modulator. In this instance, overmodulation will result in a trace of the form shown in Fig. 7 (d), with curving of the sloping sides indicating a non-linear modulation characteristic.

Similar modulation patterns may be observed by feeding the RF voltage present in the IF channel of a receiver, through a cathode follower stage, to minimise detuning of the IF circuits, to the oscillograph, thus permitting a report to be made on the modulation characteristics of the received station. However, great care must be taken in this case to interpret correctly the sometimes misleading results obtained, due to receiver selectivity, adjacent channel interference and other phenomena.

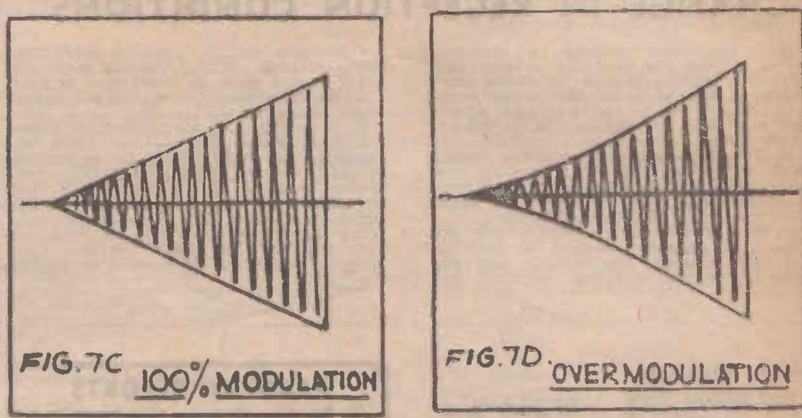


Fig. 7 (c) and (d). The trapezoid pattern for the same effects as shown in 7 (a) and (b).

DYNAMOTOR DESIGN

(Continued from page 38)

Dynamotors vary in efficiency from 45 per cent. to 69 per cent. depending on which end of the rating a frame has to work. The more watts taken from a certain frame size unit, the higher the efficiency will be. This is due to the fact that a good percentage of the loss is more or less fixed for a given frame size.

The motor side of a dynamotor with low wattage output is normally a shunt motor. When the wattage increases it is necessary to do something to keep the starting current from becoming abnormally high. For if this happens, injury may occur to some parts of the circuit, but the main difficulty is in the fusing of the units. When the starting current is too high, it takes such a large capacity fuse to handle it that there is no protection for the dynamotor even under 300 per cent. overload.

The starting current is reduced by adding series turns to the field coil, thus compounding the motor end. It is possible in this manner to bring the starting current within allowable limits, but in doing so some regulation must be sacrificed. This is due to the added IR drop in the input circuit, which changes between no load and full load conditions.

Dynamotors are required to start fast and, in many cases, very often. They often must operate at —55°C after soaking at this temperature for a long period of time. These starting characteristics are obtained by the same series field that is used to reduce the starting current. This gives the necessary torque for quick starts and fast acceleration even at the very low temperatures.

All dynamotors are required to operate in a smooth and non-vibrating manner. This is accomplished by dynamically balancing the armatures. To dynamically balance an armature, it is set up on spring supported bearings and the amount of unbalance is read on a meter. At the same time a stroboscope lamp is synchronised with the point of unbalance, so that by reading the point shown while the armature is rotated, the operator knows where to add balancing solder to overcome the unbalancing couple.

Vibration may also be caused by rough bearings or by bearings that have been exposed to dirt and have picked up some dirt in the grease. The normal allowable maximum amplitude of vibration on the heads of a dynamotor is in the neighborhood of .0007in. as measured on a vibrometer. The vibrometer is an instrument that multiplies small vibrations by means of a mirror and light beam, so that when the period of vibration is fast enough, the amount of movement shows up as a solid band of light on a calibrated glass scale.

Multiple Input-Output Designs

All of the preceding discussion has been concerned with single input, single output units. Dynamotors have been built with as many as five individual windings. These windings have been divided into units with single input and four outputs or with double inputs and triple outputs. Any variation is possible, because any winding may be used either as an input or output by using the proper turns and wire size and making the correct connections.

A very desirable quality in a dynamotor would be to have a constant output voltage regardless of changing input voltage or load. A satisfactory way of doing this without the use of external regulators has not been devised, but engineers are working on this problem, and some preliminary patents have been filed. Units are being built, that have regulated outputs, by using a carbon pile regulator and they have proven very satisfactory.

A great deal of engineering effort is being applied toward the goal of smaller units and higher outputs along with the research toward regulating inherently. It should not be too far in the future before major developments are available to dynamotor users.

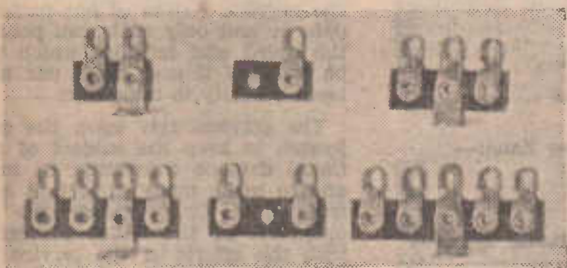
(Courtesy "Communications")

Around The Industry

INSULATED MOUNTING STRIPS

Of particular interest to the radio constructor is the recently introduced range of Teletron insulated mounting strips, which have unlimited applications in radio, electrical and electronic equipment.

Designated type SM mounting strips, they are fitted with special anti-twist brass lugs which are silver-plated to provide a quick and efficient soldered connection. These lugs are rigidly mounted on a high grade phenolic laminated paper sheet material having a high dielectric constant. To permit the easy mounting the strips are also fitted with standard mounting holes or special mounting lugs.



Also being marketed by this firm is a miniature 4-pin plug and socket of a new, modern design. The socket lugs are numbered to simplify connections, whilst the pins of the plug are off centred to prevent incorrect insertion. This is also fitted with a screw top thus permitting a neat connection.

This plug and socket will be found admirably suitable for attaching to speakers, or for use in amplifiers, receivers or any other application where a small, compact unit is required. The retail prices are: 8d. for the socket and 8½d. for the plug, and these are now available from most radio suppliers.

All trade inquiries should be directed to the local agents: Keltron Electric Products Pty. Ltd., 55 York Street, Sydney, or to the same firm at Bromham Place, Richmond, E.1, Victoria.

NEW RANGE OF FILTER CHOKES

From Ferguson's Radio Pty. Ltd. come details of their new range of power supply Filter Chokes. In keeping with modern trends these all feature the vertical style mounting, and have an attractive crackle black finish.

The range will include all types of filter chokes required in the manufacture of power supply systems up to 250 ma capacity, and for ready reference details of these are given in the accompanying table.

With regard to the inductance rating of the choke, it should be noted that this rating is the inductance with a full DC load current plus an a-c component similar to the conditions applying when the choke is in actual operation. The inductance of any iron-cored choke can vary between a "maximum" value, when the DC magnetising current is zero, and a "minimum" value when the DC magnetising current is normal. It is this "minimum" inductance value which is the important rating to consider and consequently is the one stipulated in this chart.

Complete Range

Type No.	Minimum Inductance at Normal D.C.	Normal D.C.
C50/10	50H	10 M/A
C30/25	30H	25 M/A
C15/50	15H	50 M/A
C30/60	30H	60 M/A
C30/75	30H	75 M/A
C15/80	15H	80 M/A
C12/100	12H	100 M/A
C30/100	30H	100 M/A
C12/150	12H	150 M/A
C20/150	20H	150 M/A
C12/200	12H	200 M/A
C16/200	16H	200 M/A
C10/250	10H	250 M/A
C20-5/250	20/5H	50-250 M/A

Supplies of these chokes are now available from most radio retailers, whilst any trade inquiries should be sent direct to the manufacturers, Ferguson's Radio Pty. Ltd., McMahon's Street, Willoughby, N.S.W.

Special Chassis Available

In response to recent inquiries, F-N Radio now advise that they have in stock chassis for the Miniminor Portable and AC Mantel receivers as described in the February and March issues of "Radio Science."

It is understood that limited supplies only are available, and the price is 14/6 for the Portable and 11/6 for the Mantel receiver chassis. In both cases freight or postage is extra. Address your inquiry to F-N Radio and Television Co., 265 Military Road, Cremorne, N.S.W.

W.A.Z. BOUNDARIES

(Continued from page 39)

Zone 30—Eastern Zone of Australia:—

Australia	VK
New South Wales	VK2
Queensland	VK4
Victoria	VK3
Tasmania	VK7
South Australia	VK5
Islands south of Lat, 11 S. and west of Long. 153 E.	

Zone 31—Central Pacific Zone:—

Hawaiian Islands	KH6
Ellice Islands	VR1
Gilbert Islands	VR1
Baker, Howland, American Phoenix Islands	KB6
Midway	KM6
Palmyra Group, Jarvis	KP6
Wake Island Group	KW6
Johnson	KJ6
Islands between Lat. 11 deg. S. and 40 deg. N. and between Long. 163 deg. E. and 140 deg. W.	

Zone 32—New Zealand Zone:—

New Zealand	ZL
Loyalty Islands	
Tahiti	FO
Fiji	VR2
New Hebrides	FU8, YU
Samoa	KS6
New Caledonia	FK
Pitcairn Islands	VR6
Chatham Islands	
Islands south of Lat. 11 deg. S. and between Long 163 deg. and 120 deg. W.	

Zone 33—North-western Zone of Africa:—

French Morocco	CN8
Spanish Morocco	EA9
Rio de Oro	
Tunisia	FT4
Alberia (Northern and Southern)	FA
Ifni	
Madeira	CT3
Canary Islands	EA8

Zone 34—Northern Zone of Africa:—

Libya	
Egypt	SU
Anglo-Egyptian Sudan	[illegible]

Zone 35—Western Zone of Africa:—

French West Africa	FF8
Nigeria	ZD2
Ivory Coast	ZD4
Gambia	ZD3
Cape Verde Islands	CR4
French Guinea	
Liberia	EL
Portuguese Guinea	CR5
Dahomey	
Ashanti	
Sierra Leone	ZD1
Senegal	
Gold Coast	ZD4
French Sudan	FD8
Togoland	FD8, ZD4

Zone 36—Equatorial Zone of Africa:—

Angola (Portuguese West Africa)	CR6
Cameroons	FE8
Spanish Guinea	
French Equat. Africa	FQ8
Belgian Congo	OQ5
Northern Rhodesia	VQ2
Cabinda	
Rio Muni	
Gabon	
St. Helena Island	ZZD7
Ascension Island	ZD8

Zone 37—Eastern Zone of Africa:—

Mozambique (Portuguese East Africa)	CR7
British East Africa	
Kenya	VQ4
Uganda	VQ5
Tanganyika	VQ3
Nyasaland	ZD6
Ethiopia (Abyssinia)	ET
Italian Somaliland	
British Somaliland	VQ6
French Somaliland	FL8
Eritrea	16
Zanzibar Islands	
Socotra Islands	
Mafia Islands	

Zone 38—Southern Zone of Africa:—

Union of South Africa	ZS
Southern Rhodesia	ZE
Swaziland	ZS
Basuotoland	ZS
British South-west Africa	ZS3
Bechuanaland	ZS
Tristan de Cunha Island	ZD6
Gough Island	
Bouvet Island	

Zone 39—Madagascar Zone:—

Madagascar	FB3
Reunion Island	FR9
Seychelles Island	VQ9
Admirante Island	
Mauritius Island	VQ8

Zone 40—North Atlantic Zone:—

Greenland	OX
Iceland	TF
Svalbard (Spitzbergen)	

3-WATT CATHODE COUPLED AMPLIFIER

(Continued from page 19)

measurements on this particular amplifier, but whatever distortion does exist is not noticeable to the very critical ear, which, after all, is the final judge in these matters.

Advantages of System

If the cathode follower can be said to have any advantage over the conventional amplifier it is this:—that it is not necessary to use push-pull valves to minimise distortion. Hence for ordinary home use where low power is required, the main amplifier can be greatly simplified, yet retain the quality of performance obtainable with push-pull output push-pull. Output cathode followers are quite unnecessary from the point of view of distortion.

However, the main disadvantage of cathode follower output is the difficulty of obtaining sufficiently high driving voltage. This can be obtained from a resistance-coupled stage by using a B supply of 400 or 500 volts, or the necessary driving voltage may be obtained by using an audio transformer as in the amplifier under discussion. This latter method may be objected to on the grounds of cost, but when it is realised that a good quality speaker and pick-up cost about £15 each, an audio transformer is only a small item in the cost.

(To be concluded)

A CORRECTION

In the description of the two valve receiver in the February issue, mention was made of a standard type of coil being used. This statement is aut to be misleading, since the coil in question is a special FN type having a larger than usual reaction winding. In view of the tuning condenser being of the solid dielectric type, these additional turns on the reaction winding are necessary to provide efficient reaction control over the entire tuning range.

Problems of Military Radio Communications

(Continued from page 11)

But the service laboratories alone cannot possibly suggest, sponsor and direct all of the work which will be necessary. Such problems as these cannot be reduced to terms of money and solved simply by contracting for a certain amount of effort for a year or two. Their solutions will come from the mind of man, not from his hands. They require the careful thought and patient research of many men, their findings properly evaluated and correlated with other efforts, verified by experiments and aided now and then by sparks of genius to reconcile the irritational and so accomplish the impossible. Such work cannot be purchased; it cannot be hired; it must be inspired.

The radio engineering profession is challenged to produce advances in its science and technique as far-reaching as those being made in other fields, for communications are the nervous system of our national defence and only radio can provide the speed and mobility which will be essential if ever again our national security is imperilled.

The services rely upon the profession to keep the subject of national defence constantly in mind and to make many important contributions. Only through the co-operation of the entire profession with the efforts of the service laboratories can our full scientific potential be realised.

—Courtesy Proceeding I.R.E. (U.S.A.)

Computer-Mathematical Merlin

(Continued from page 8)

ticeably affecting technological progress. Many problems that have been economically insoluble until recently are rapidly being brought under control. In the military field, new weapons of amazing accuracy and power are being investigated. In meteorology, computers are making it possible to utilise accumulated data more completely, thus improving the accuracy and the advance time of weather forecasting. In engineering, more accurate predictions of stresses and performance improve safety, and may reduce safety factors and costs. In science, the computer is being used to explain the complex relations of nature, including the behavior of the atom and its components.

BATTERY OPERATED OSCILLATOR

(Continued from page 23)

in series with the plate circuit or screen circuit and note the effect of the increased signal on the plate or screen current.

As the automatic volume control increases due to increased signal strength the plate or screen current will be reduced. The effective change is again an indication of the automatic volume control voltage.

Valve and Circuit Testing

Frequently in radio service work, various components will test in order under normal testing conditions, but when operated in a receiver may cause considerable trouble. In such cases, it is obviously necessary to test these components under their actual working conditions.

The oscillator may be used very conveniently for this function as it can supply an unvarying signal strength to the receiver and consequently any variation which takes place in the output is due to some fault in the receiver itself. By feeding a signal of broadcast frequency into the aerial and earth terminals, and by adjusting the attenuator unit to a reasonable signal strength various components in the receiver can be replaced to see whether they are working satisfactorily or not. It is advisable to use some form of output meter to measure the output being obtained as the ear is very inaccurate in judging changes in signal strength.

In this way if a valve is suspected of being faulty, it may be tested under its actual conditions by replacing with one known to be good. Any increase in output represents greater gain from the new valve than from the old, and consequently the old valve may be considered as being inefficient. Various minor components such as resistors and condensers may be tested in a similar manner.

Signal Tracing

An efficient means for locating a fault in a radio receiver consists of what is known as *"stage testing."* Stage testing is means of localising particular faults being experienced to one individual stage. The various components of this stage may then be checked quite readily, resulting in a greatly reduced time of operation.

This operation can be carried with an oscillator in the following manner. Switch on and set the dial to the correct intermediate frequency of the receiver under test. Feed this signal into the grid of the last intermediate valve, and the receiver is now functioning only from the last intermediate stage.

Consequently if the function here is quite normal, it immediately eliminates the second detector, power valve, speaker and power supply unit. The hot lead should then be transferred to the first if or first detector and if the receiver still continues to function then the fault exists before this stage, as the remainder of the receiver has been proved to be in good order.

Switching now to a broadcast frequency and feeding the signal into the aerial and earth terminals will locate the fault in the remaining stages.

K. B. WARNER

(Continued from page 15)

two-way communication across the Atlantic using amateur radio frequencies. This was the birth of international communication for him. Behind his mind he thought of a great international body binding together the amateur radio operators of the world. With the launching of the I.A.R.U. in Paris, 10 years later, another dream had become a reality.

But still K.B.W.'s job was unfinished. With communication to the Antipodes established, he turned his thoughts to the higher frequencies, high fidelity audio amplifiers as plate modulators, and in recent years single side-band and u.h.f. transmission.

Although he is not now with us, K.B.W.'s work will live for ever. QST is a living monument to this great man.

Perhaps the simplest token of esteem with which he was held in U.S.A. was the letter I received from the acting A.R.R.L. secretary (Mr. A. L. Budlong). It read:

"Your message of condolence on the passing of Secretary Warner was greatly appreciated by both Mrs. Warner and the staff here at headquarters.

"The many kind letters and telegrams received emphasise the place he held in amateur radio. The headquarters staff will do its best to carry on where he left off."

Vale, K.B.W.!

SCRATCH FILTER UNIT

(Continued from page 32)

point where a gain of 100 could be realised, the input capacity would be approximately 5750 mfd. The grid-to-plate capacity in this calculation is 47 mfd because of the addition of C3 between the grid and plate. This input capacity is large enough to shunt the higher audio frequencies and the effective capacity of the stage can be controlled.

Referring to Figure 1 again, the operation of the scratch eliminator can be summed up as follows. During the low level passages or during the absence of high frequencies, there is insufficient voltage coupled to the diodes to overcome the delay voltage and there is no rectification. Since there is no current flow in the resistor R6, the gain of the reactance valve will remain at maximum. This results in maximum input capacity and a shunting of the audio signal.

If, however, there is sufficient signal to overcome the delay voltage, rectification will take place. The current flow in R6 will decrease the gain in the reactance tube and the input capacity will decrease. This decrease will allow the higher frequencies to pass. Although this action has been described as a chain of events, it should be borne in mind that this shunting effect is constantly changing, resulting in good reproduction of the recorded music with a minimum of surface noise.

The complete unit can be built up in small chassis and readily added to any present amplifier. The switch shown in the circuit as S1 is for the purpose of disabling the unit. With the switch open current flowing through the bleeder network R12 and R11 biasses the reactance valve to cut-off and there is a minimum of shunting of the audio frequencies.

WANTED . . . TECHNICAL ARTICLES

YOU can be an author, a man of distinction if you heed these words. As the policy of this magazine is to provide a coverage of the radio and electronic fields, articles of a suitable nature dealing with any phase of these topics will always be considered for publication in this journal.

All you need do is to write about 2000 to 2500 words dealing with some item of interest or describe equipment you may have constructed, and which should be of interest to our readers. Whilst we prefer double spaced typewritten copy, this is not absolutely essential providing your ideas are sound. Just send the copy along, and if necessary we will decipher your writing and rework it into readable English. Put in any sketches and diagrams required, and these will be drawn up by our own draughtsman.

All manuscripts should be forwarded to the Editor, Box 5047, G.P.O., Sydney, and payment will be made for all accepted material on publication.

The Mail Bag

W.R.F. (Prospect, S.A.) forwards his subscription to RADIO SCIENCE and mentions he is particularly interested in the Short Wave Notes.

A. Your subscription was passed on to the Subscription Department for attention. No doubt by now you will have received the issues requested. Your remarks about including more SW station addresses have been noted and will be passed on to our correspondent. Undoubtedly he will be able to include this information in his notes from time to time. We appreciate your remarks about the magazine, and are pleased to hear you think it is the best technical journal in Australia!

A.W.J.H. (Townsville, Q'ld.) intends coupling the Williamson phase inverter to a direct coupled push pull output, but is having trouble with certain calculations involving Kirchoffs Laws.

A. To date, there has not been an opportunity to check through the calculations you supplied, but an endeavor will be made to do this in the near future and a reply will be sent direct. At the moment there are no plans for a direct coupled circuit as you mention, but it may be possible to cover this topic in a later series of articles. No doubt this would be of considerable interest to many other amplifier enthusiasts. Many thanks for the kind remarks about the magazine.

M.H.S. (Woolowin, Brisbane) is building up the Signal Tracer described in the April, 1948, issue and asks for some additional information.

A. The grid return you refer to connects to A minus of the chassis of the tracer. It should be noted that in the circuit diagram the A— and B— minus leads are shown connected together. This is incorrect and the A minus lead should be earthed. Also the .025 meg potentiometer should be a .025 meg Fixed resistor and the 500 ohm resistor between the points B, should be a 500 ohm potentiometer. The power supply you mention should be satisfactory, providing the 1.4 voltage is constant. A fluctuating voltage here may exceed the tolerances allowed, and damage the filament. Shielded wire is not necessary for the probe. In the original, this consisted of a length of three way flex. One lead for high tension, and the other two for the filament plus and minus leads. We would be pleased to hear of your results with this unit.

E.R.H. (Randwick, N.S.W.) writes in for a back issue and mentions he is interested in building up a speaker dividing network.

TECHNICAL QUERY SERVICE

Readers are invited to send in any technical problems, either dealing with our circuits or of a general nature, and an earnest endeavor will be made to assist you through the medium of these columns. For convenience keep all letters to the point, with questions set out in a logical order, as space is rather limited.

All technical enquiries will be dealt with in strict rotation and the replies will be published in the first available issue of the magazine. Address all letters to RADIO SCIENCE, Box 5047, G.P.O., SYDNEY, and mark the envelope "Mail-bag."

A. The issue requested has been forwarded, and this contains all the information you require. We would be pleased to hear of your results with any speaker network system when you complete it. Thanks for the appreciative remarks.

K.E.J. (Forbes, N.S.W.) renews his subscription and says: "I look forward to receiving your book each month and read it from cover to cover. The articles on Television, FM and Navigational Aids, etc. make very good reading in my opinion."

A. Thanks for the subscription, K.E.J., and this has been passed on to the Subscription Department for attention. As the November and December issues were combined, your new subscription will take effect from the March issue. We appreciate your remarks about the magazine, and are pleased to hear that you enjoy reading each issue.

H.R.P. (Dolls Point, N.S.W.) intends building up the "World Wide Six," described in the February issue, and asks several questions about this receiver.

A.: The speaker used is a permagnetic type with a 5000 ohm transformer to match the 6V6G. The second 6SK7-GT could be replaced by an EBF 35, and by using a 6SJ7-GT as audio amplifier considerably more audio gain could be obtained. The Dual Wave Five in the September, 1948, issue used this scheme, and we suggest you refer to this for the circuit details. One point to watch is that the higher gain does not cause any instability, and it will be necessary to use care in positioning the various leads. The coil unit is readily obtainable from most radio stores, and they will be able to let you know the price between this and the dual wave unit. We would be pleased to hear of your results with this receiver when you have it completed.

B.J.S. (Hollywood, W.A.) enjoys reading every issue and draws our attention to an incorrect mailing address.

A.: Many thanks for the letter and wrapper, B.J.S. This has been passed to the Subscription Department, and the street number has been altered accordingly. You should not have any future worries on this point. Your kind wishes are appreciated.

A.R.C. (Homebush, N.S.W.) writes: "The subject matter contained in Radio Science in its present form is splendid. The scope covered is wide and very interesting."

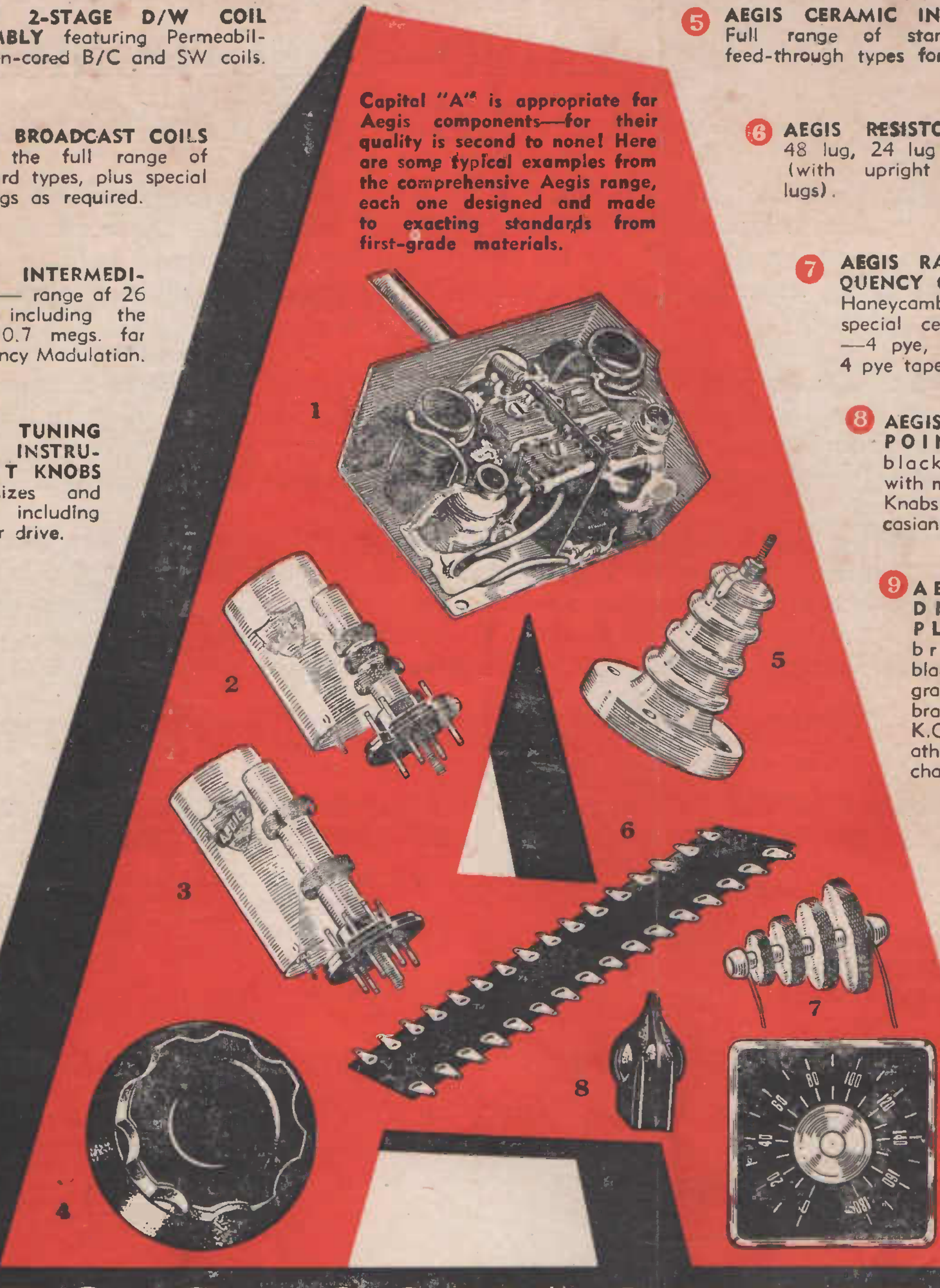
A.: Your new address has been noted, and this will take effect from the March issue. We appreciate your remarks about the magazine, and feel sure all future issues will interest you just as much.

G.R.F. (Mosman, N.S.W.) is interested in making recordings, and asks if we intend describing the construction of a magnetic wire recorder.

A.: We have had several other inquiries for this equipment, but to date have done nothing along the lines you suggest. The main difficulty at the moment is to obtain driving motors having suitable operating characteristics. This is important, otherwise snarling and breaking of the wire will result. Also it is practically impossible to obtain the correct type of recording wire. The same views hold for the magnetic tape recorder, but when equipment becomes available we will certainly describe a suitable unit. We are pleased to hear you enjoy reading RADIO SCIENCE, especially the articles on servicing and sound equipment.

K.S.M. (Toowoomba, Qld.) renews his subscription and asks about grounded-grid amplifiers.

A.: A grounded-grid type triode amplifier is a recently developed circuit finding application in the r-f stage of high frequency receivers in place of the more usual pentode. In the circuit, the grid of the valve is grounded (r-f potential) and the input signal is taken to the cathode. Under these conditions the valve still operates as an amplifier since the plate current is controlled by the grid-cathode potential. Instead of varying the grid potential, maintaining a fixed cathode potential, the grid is now fixed and the cathode potential is varied. The grounded-grid also acts as shield between the input and output circuits, thus preventing any feedback or oscillation effects. Main disadvantage of circuit is inherent degeneration which tends to offset the input signal.



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