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Molecular Requirements for Synthetic Rubbers

By W. O. BAKER
Chemical Laboratories

RUBBERY substances consist basically of long chains of atoms to which other atoms may be attached in small groups that occur repeatedly and often regularly like the links along a chain. There are hundreds of atoms in one of these "macro" molecules. It is the particular arrangement and the active forces between these molecules that are responsible for the elastic properties of many substances. The structure of the molecules of most synthetic rubbers as well as that of natural rubber is so complex, however, that efforts to determine, by direct study of the commercial products, what produces their rubbery characteristics have yielded results that are difficult to interpret. Progress in solving the puzzle has recently been made by starting with simple chain compounds and forming from them, by known chemical modifications, substances that have some of the properties that are found in natural rubber.

Studies of these "model" chain compounds indicate that the long-chain molecules of rubbery substances must have forces between atomic groups which are small enough to permit twisting and kinking of the chains. There must also be lateral forces to hold adjacent molecules together, like a bundle of sticks, especially when the substance is stretched. Moreover, the molecules must have side groups to avoid the close packing, when unstretched, that is characteristic of crystals.

The simplest carbon-chain molecules are those of the paraffin group, of which poly-

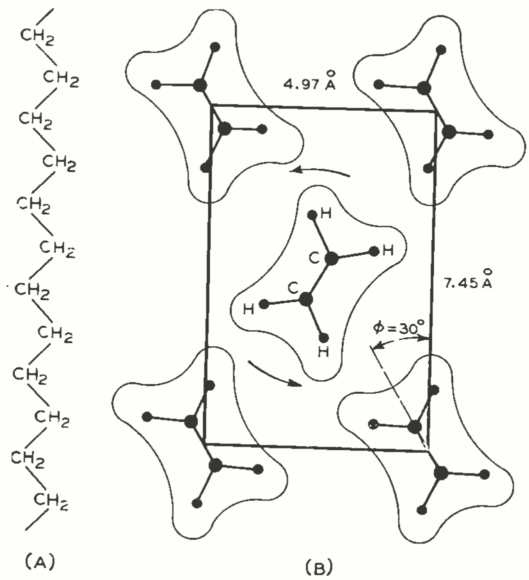


Fig. 1—Rubbery substances consist of long chains of carbon atoms to which other atoms are attached as side groups, replacing hydrogens. These chains, without the side groups, are illustrated by the structural formula of the polyethylene molecule. At the right are shown cross-sections of these chains. The enclosed areas represent electrical fields around them.

ethylene is an example. Its structure is shown schematically in Figure 1. This polymer is somewhat elastic at high temperatures but it then lacks tensile strength, which indicates weak lateral attractive forces between molecules. At ordinary temperatures, these chain molecules also form semi-crystalline solids which are rather inflexible.

Intra-chain stiffness can be overcome in these substances by introducing oxygen or other atoms between some of the carbon atoms. This also produces unneutralized lateral forces which tend to attract adjacent molecules, a tendency that likewise results from adding certain side groups to the molecules, such as phenyl—C_6H_5. To prevent this attraction from progressing to the extent of causing crystallization in the unstretched condition, other side groups such as methyl, CH_3, are introduced at regular intervals along the chain, as is illustrated schematically in Figure 2 for polypropylene sebacate.

The Laboratories' studies of these polyesters indicate that the characteristic of many rubbery substances which gives them tenacity is the formation of atomic groups in which some of the positive and negative charges have been separated, thereby giving the group dipole properties. These separated charges attract their opposites in the dipoles of molecules on both sides of them and provide the strength and toughness required in synthetic rubber. This head-to-tail arrangement of the dipole groups orients them in layers which are illustrated in Figure 2 by the sloping lines. X-ray diffraction studies and measurements of the modulus of elasticity have confirmed this dipole layer formation in many model rubber compounds. If the dipole forces are too strong, however, crystalline solids result. This condition can be modified, as stated above, by introduction of methyl, CH_3, side groups at or near the polar layers. Similar results are obtained by placing methyl groups actually within the polar layers of the model rubber compounds.

When natural rubber is stretched, its

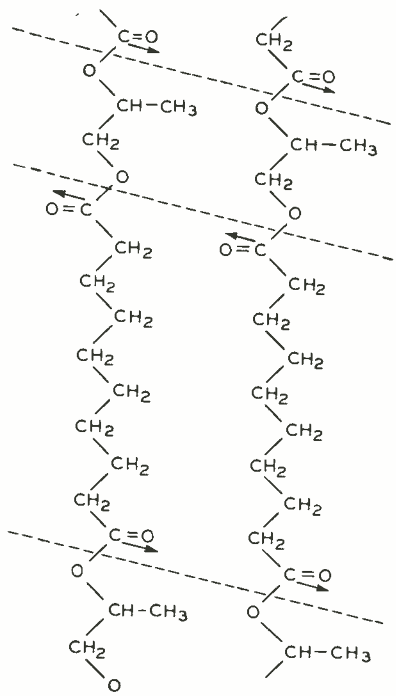


Fig. 2—The broken lines across this structural formula of polypropylene sebacate show the layers within which there are attractive forces caused by separated positive and negative electrical charges. These attractive forces provide the strength and toughness that is required of rubber

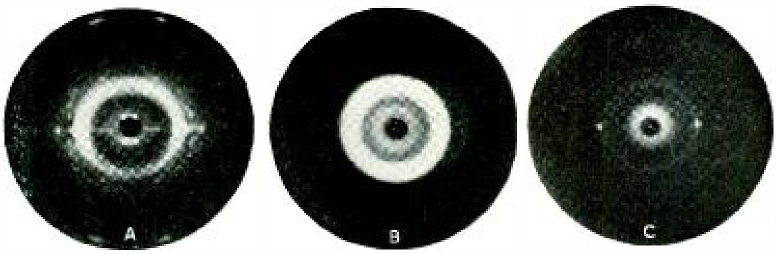


Fig. 3—X-ray diffraction patterns of polypropylene sebacate. Pattern A shows marked crystallinity. It was made after the specimen had remained stretched twenty-four hours. Pattern B was unstretched and is amorphous. Pattern C shows little crystallinity because it was photographed immediately after stretching

tensile strength becomes greater because crystals are formed with consequent closer packing of atomic groups and increase of the intermolecular forces. The same is true of the polyester "model molecules" used in these studies. Figure 3A shows an X-ray diffraction pattern of polypropylene sebacate from a specimen which was elongated sixfold at 25 degrees C. after the gum had been vulcanized to keep it from creeping, since this polymer is fluid at slightly above room temperature.

Polyester models show the properties of a true rubber by the complete disappearance of crystallization on relaxation. Figure 3B was made from a relaxed specimen which had been repeatedly stretched. The pattern is typical of amorphous scattering. In contrast to natural rubber, however, crystallinity does not develop immediately on stretching these polyesters. This is illustrated by comparing the relatively disordered pattern of Figure 3C, where the specimen was stretched and photographed at once, with the comparatively rich crystallinity of Figure 3A, in which case it remained stretched twenty-four hours before exposure. Delay of orientation on stretching limits the "instantaneous" tensile strength of the compounds and is accompanied by internal friction with consequent hysteresis loss. Nevertheless, the gum stocks of these model polymers exhibit high elasticity and quick recovery from deformation.

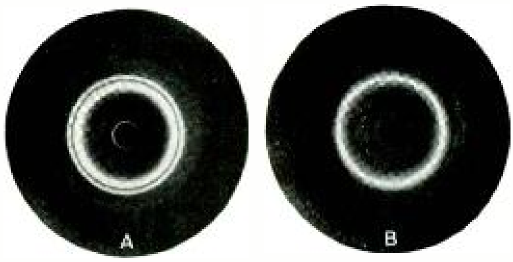


Fig. 4—Adding methyl groups to polyethylene sebacate causes an effect like random rotation of the molecules about their long axes. This has made the outer ring of A disappear in B, which was taken after methyl radicals had been added

When methyl side groups are added to chain molecules to prevent the polymers from crystallizing at room temperature, they may be inserted in different parts of the molecule and their effect on the atomic spacings depends on their location. If the methyl groups are introduced next to the ester group of a dipole layer, Figure 2A, X-ray diffraction studies show that the molecular chains spread and increase the lateral spacing by a few per cent.

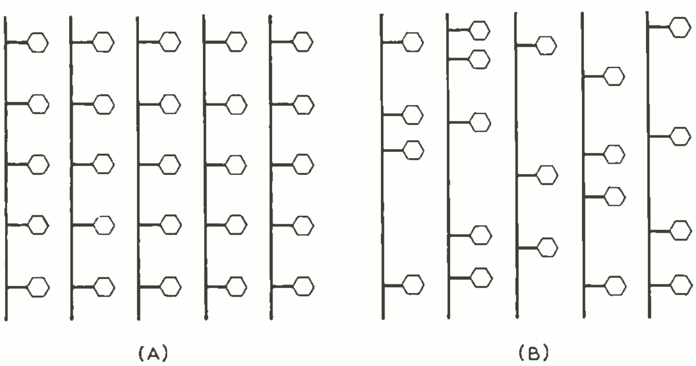


Fig. 5—In natural rubber and in an ideal synthetic rubber the points of attraction of adjacent chain molecules come opposite each other when the specimen is stretched, as is indicated at A. Actually in GR-S rubber the phenyl groups, which provide these points of attraction, are irregularly aligned, as shown at B, and thus the product is weakened

Another result of introducing methyl groups is an effect like random rotation of sections of the molecules about their long axes. This causes disorder which can be detected by diffraction patterns. Thus Figure 4A, obtained from polyethylene sebacate before introducing methyl groups, shows two sharp and intense outer rings. Only one can be seen in Figure 4B, which was made from this polymer after substituting methyl groups in it. This indicates that the particular orientation around the long-chain axes, which is responsible for the other ring, shown in Figure 4A, has deteriorated.

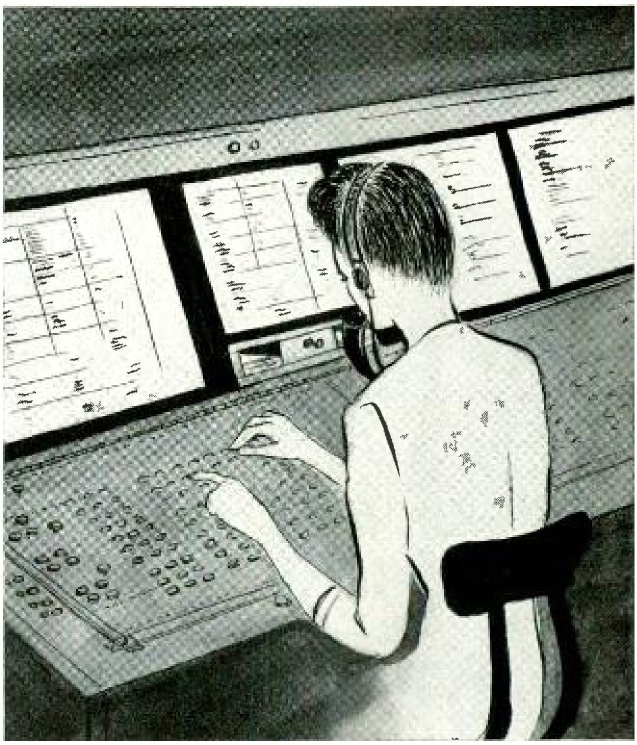
Since the forces between chain molecules drop off at least as the third power of the mean separation of attraction centers, small changes of spacing may make a large difference in the stiffness of the material. The disordering noted above is accompanied by such an increase in spacing and this may convert a hard plastic into a rubbery material.

Application of these principles to the GR-S synthetic rubber which is now being made in large quantities in this country is illustrated by the schematic diagrams of Figure 5. An ideal GR-S, Figure 5A, would have a structure analogous to the polyester models and the attraction forces between parallel molecules would be supplied by the phenyl groups. On stretching, these groups would form layers. Actually the condition in GR-S is probably more nearly represented by Figure 5B. The styrene residues, with their phenyl groups, occur irregularly along the molecular chains. Therefore, when the chains are roughly aligned by stretching, the phenyl groups in adjacent chains do not all come opposite each other. Thus, at many points high attractive forces remain uncoördinated and help little in tying the gum together. This deficiency can be lessened by more complete polymerization of the gum, which increases the probability of some of the phenyl groups of any two adjacent chain molecules being in position to attract each other. In this connection it may be noted that fillers also help to increase the strength of rubber compounds by attaching themselves to the uncoördinated polar groups.

THE AUTHOR: W. O. BAKER joined the Laboratories in 1939 to undertake investigations of the physical properties and molecular structure of polymers and plastics. Recently, studies of synthetic rubber have demanded his time in connection with the United States Government rubber program. After being graduated from Washington College in 1935, Dr. Baker went to Princeton University for graduate study. He held the Harvard fellowship at Princeton and received his Ph.D. there in 1938. The following year he remained as Proctor Fellow to pursue studies on solid dielectrics.

Manual Calls in Crossbar Toll

By A. G. LANG
Switching Development



WITH the No. 4 toll switching system,* recently installed in Philadelphia, all connections are made by crossbar switches under the control of electrical pulses. When the incoming trunk is of the dial type, from either an office in the Philadelphia area or from a distant toll office, these pulses are received over the trunk from the originating end. For such calls, no operators are involved at the crossbar office. Many toll lines, however, are not arranged for transmitting switching pulses, and even in the larger cities some of the boards from which outgoing toll calls may be placed are of the manual type. It was necessary, therefore, to provide also a manual board from which the crossbar switches could be controlled, and for this purpose the No. 4 toll board was developed as part of the crossbar toll system. As evident from the illustration at the head of this article, the No. 4 board differs from the more usual type in having neither cords and plugs nor jacks; only keys and lamps require the operator's attention. Calls as they come in are connected to an operator's headset automatically, which she sets up by operating keys in the two large groups in front of her.

To establish a connection through the toll office, only three keys need be operated, and these are in the three columns at the left of the large bank. For through or outgoing calls leaving over manual trunks, these are the only keys that need be operated, but for calls terminating in Philadelphia and for through and outgoing calls leaving over dial trunks, the large bank of keys at the right is provided in addition for reaching the subscriber at the terminating end.

*RECORD, *April*, 1944, *p.* 355.

Each switchboard position has three loops over which the operator may receive calls and establish connections, and calls are connected to these loops at the operator link frames.* The term loop is used because the circuit between the incoming toll line and the switches is looped to the operator positions as indicated in Figure 1 during part of the time the operator is handling the call. After the desired connection has been established, the operator's position is in most cases automatically released, with the result that the incoming line is connected to the switching equipment without passing through the No. 4 crossbar toll board.

To illustrate the operation, consider a call coming in over a manual toll line for completion to a subscriber in a dial office in a town reached over a dial toll line from Philadelphia. When the call is connected to her position, the operator is notified by lighted lamps and by zip tone in her headset, and acting on these cues she gets the connection wanted from the originating operator. On bulletins in front of the No. 4 operators are the names of the frequently called cities, together with the three-digit codes required

*RECORD, *July*, 1944, *p.* 454, *and August*, 1944, *p.* 481.

to reach a trunk to them through the crossbar toll system. The operator, after noting the required code, operates keys in the first three strips to select the proper trunk, and then operates keys in the large bank to select the office and line at the distant end of the trunk. She then presses a start button in the extreme right-hand column.

Operation of the three code keys caused a marker to be seized, which at once started finding an idle trunk in the desired group, and then establishing a connection to it through the crossbar switches. As soon as the trunk is found, it seizes an outgoing sender, which will be used to transmit the required pulses to the distant toll office. The marker releases immediately after it has established a connection to the trunk. At this time the code keys will also release. These operations will usually be completed by the time the operator has finished pressing the keys for the connection wanted at the distant end. When the operator presses the start key, the sender associated with her position starts transmitting the number wanted to the outgoing sender, and the loop and position, which up to this time have acted as a unit, are both separated electrically into two halves. The sender is associated with the outgoing or front half of the loop and proceeds to send out pulses to the outgoing sender. The incoming or back half of the loop, however, is disconnected from the operator's headset so that another call may be handled.

The next call will be connected to the back half of one of the other loops. The operator will receive signals and get the connection desired as before, and will start operating keys to set up the new code in the crossbar toll office. In the meantime, the sender has been transmitting pulses for the preceding call, and, as the pulses for each digit are sent, the key operated for that digit is released. As soon as all have been sent, the outgoing half of the position will be free to accept the digits of a new call. Since less than a second is ordinarily required to send the pulses for the previous call, they will have been sent before the operator has finished the three-digit code for the next call.

This division of the loops and positions into halves permits calls to be handled more speedily by enabling the operator to receive the number wanted for a call and to operate the three code keys while awaiting the completion of the preceding call. Where the call requires that only the three code keys be operated, however, the division does not come into play, and the position will automatically release as soon as the marker has established the connection through the toll office. Calls requiring a connection to a ring-

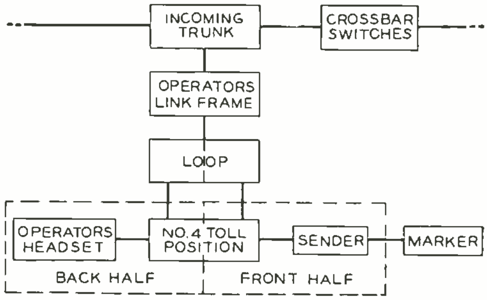


Fig. 1—From the operator's link frames, calls are extended to the No. 4 switchboard over "loops," three of which run to each position

down manual trunk are of this type, since for such calls the originating operator gives the order verbally to the distant operator after the connection has been established.

Such, in brief, is the usual operating procedure at the No. 4 toll board. There are a number of other types of calls that the operator must handle, however, and to permit her to perform her work effectively on all types of calls and under all conditions, the board is provided with a number of keys and lamps in addition to those already referred to. These are shown on the plan of the key shelf given in Figure 2.

Each of the three loops associated with the position has a connect key and three lamps: a guard lamp, a busy lamp, and a supervisory lamp. The colors of these lamps, blue, green and red, are indicated on the drawing. The connect key and the three lamps for each loop are in Column 4 of Figure 2. The busy lamp is lighted all the time a call is associated with that particular loop. The guard lamp flashes all the time the loop is connected to the back half of the position, and is extinguished after the splitting operation. The supervisory lamp gives indication of conditions on the outgoing trunk, such as that a subscriber has answered or disconnected. The connect keys are used with a locked loop as described later.

The manual trunks over which the operator receives calls or to which she may establish connections are either of the ringdown or straightforward type. The former will not transmit switchhook signals, and ringing must be applied to them to attract the attention of the operator at the distant end. Straightforward trunks, on the other hand, will pass switchhook signals and automatically call in the distant operator. The operating procedures for the two types of trunks, therefore, differ somewhat, and whether an incoming call is over a ringdown or straightforward trunk is indicated to the operator by the tone she receives when her headset is connected to the loop. For a ringdown trunk she receives a single zip tone, while for a straightforward trunk she receives a triple zip. This latter tone is also heard by the originating operator, who at once states the connection she wants. When a No. 4 operator receives a single zip indicating a ringdown trunk, she says "Philadelphia," which is a request to the originating operator to state the connection she wants.

The center pair of keys in Column 3 is for recalling the operators on ringdown trunks. The RB key (ring back) signals the calling operator, while the RF key (ring forward) signals the called end of the connection. In this same column are two other pairs of keys. Those of one pair, the DB (disconnect back) and DF (disconnect forward) keys, are used for disconnecting the connection in both directions, or merely toward the forward end. Those of the other pair, the LB (lock back) and LF (lock forward) keys, are for locking out the calling or called end of the connection and identifying them at the test board when trouble is encountered on them so that they will not be seized by the crossbar equipment until the trouble has been investigated and cleared.

When a call set up by the No. 4 operator finds all trunks in a toll line group busy, it is connected to an overflow trunk, which returns a flashing signal. If the calling trunk is of the straightforward type, the No. 4 operator is released, and the overflow signal is received by the originating operator. When the calling line is of the ringdown type, however, the overflow flash is given by the supervisory lamp at the No. 4 board, and an overflow signal is also given by a lighted

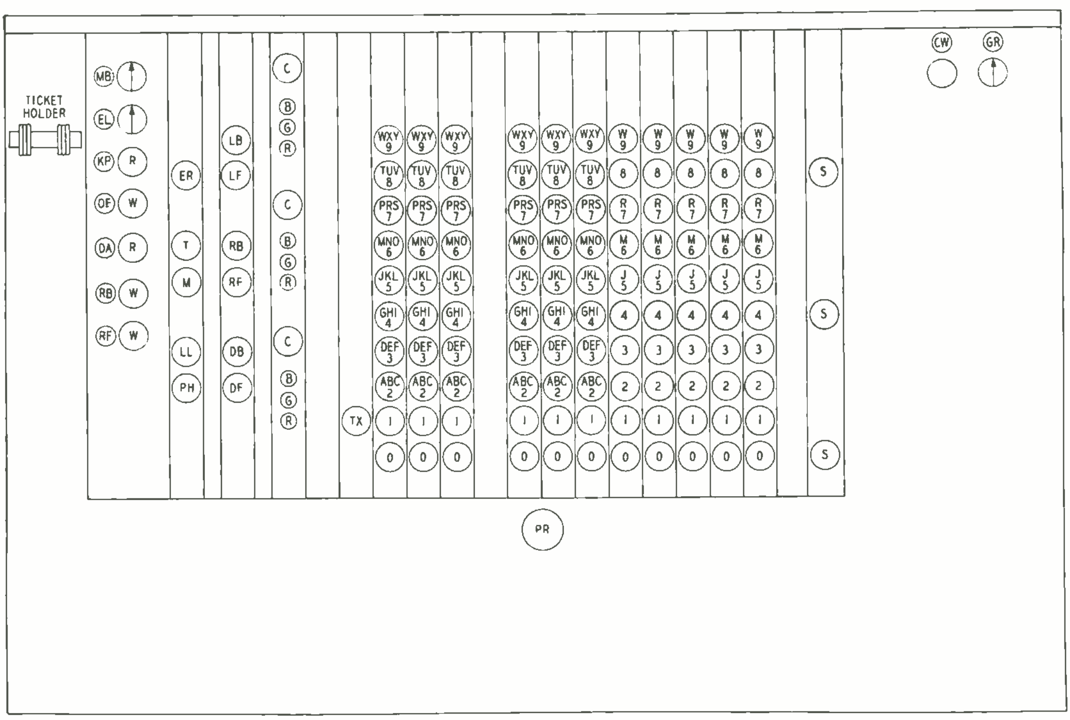


Fig. 2—Plan of key and lamp equipment at a No. 4 position

lamp, OF, as a signal that the condition must be reported to the originating operator by the No. 4 operator.

The five keys in Column 2 are rarely used. The emergency release key, ER, releases the position when it has been locked up by some trouble such as a stuck sender. The monitor key, M, permits the operator to listen, but not to talk, on a loop to enable her to make sure a connection has been properly established. After this key has been depressed, the talk key, T, must be operated if it is desired to restore the talking condition on that call. The LL and PH keys, standing for "loop lock" and "position hold," are used only when conditions make it desirable to prevent the automatic release of the loop and position that occurs under normal operating procedure. The LL key holds the loop and link between the trunk and the position so that supervisory signals may be received. While the loop is locked, the operator may disconnect her headset from it so as to handle other calls by operating PR, and may reconnect her headset by operating the connect key associated with the loop. When the PH key is operated, on the other hand, the position and loop are held only until the PR key is operated.

In Column 1, the RF lamp (recall forward) lights when the outgoing or forward end signals the No. 4 operator, while the RB lamp (recall back) lights when the originating end recalls. The DA lamp (don't answer) lights when a subscriber doesn't answer within 80 seconds after the position has released. The overflow lamp, OF, lights when all the trunks in the called group are busy, as already mentioned, or when all the overflow trunks are busy. The KP lamp (key pulsing) lights after the three code keys have been operated if the code registered indicates that further keying is necessary. The emergency listening key, EL, which is seldom used, connects the operator's headset to the loop when some trouble condition prevents its normal connection, while the MB key (make busy) makes the position busy. The GR key, at the extreme right of the key shelf, groups the position with an adjacent one to make more loops available to each operator during light load periods, and the calls-waiting lamp, CW, which is located to the left of it, indicates that calls are coming in faster than they are being answered.

For a large part of the calls that are switched to a local office in Philadelphia or to a distant toll office without encountering busy groups or other delays, these lamps and keys in the first three columns are not used. They are provided to permit the operator to act promptly and effectively on the smaller percentage of calls that encounter busy groups or that run into other difficulties of one form or another. For most of the calls, the operator is connected to the incoming call automatically, presses keys for the proper connection and is automatically released to be available for the next call.

THE AUTHOR: ALBERT G. LANG joined the Laboratories in 1920. He first worked in the toll circuit laboratory as technical assistant. During that period he attended and graduated from the Technical Assistant's course. Since 1925 he has worked on the design of toll tandem and toll switchboard circuits. In recent years he has been associated with the circuit developments of toll switchboards Nos. 1B and 3B and toll switching system No. 4. Mr. Lang studied at Brooklyn Polytechnic Institute from which he received his degree of Bachelor of Electrical Engineering in 1943.

Protecting Communications Equipment for the Tropics

By JOHN LEUTRITZ, JR.
Chemical Laboratories

IN PEACETIMES, most communications equipment is engineered and manufactured by the Bell System for use under protected conditions in temperate climates. When this equipment goes to war of global extent, however, it must function satisfactorily in an airplane at subzero temperatures, in a tank in the heat of the desert, on a landing barge exposed to salt spray, or in a muddy foxhole. Moreover, equipment can not usually be segregated for one theater of operations. A shipment en route to the Aleutians may suddenly be needed, by the exigency of war, on some tropical island in the Pacific.

For many years the Bell System has been engaged in studying the effects of environment on communications equipment which has to operate under unfavorable conditions. When the war began this store of information was placed at the disposal of our Armed Services. Research was also continued on specific problems that had been encountered, many of which resulted from amphibious operations in the Pacific.

Where the mean annual humidity is 80 per cent or more, and the daily temperature range is from 80 to 90 degrees F. throughout the year, a slight drop in temperature, caused by a vagrant breeze, may condense moisture on equipment several times a day and more frequently during the night. This moisture deposits on the surface of insulators and is absorbed by them, thus reducing their resistance and interfering with the operation of delicate electrical circuits. These effects may be prolonged or even made permanent by the presence of organic fungus growths which thrive on many insulating surfaces under the favorable humidity and temperature conditions of the tropics.

Failure of electrical apparatus during early stages of the war in the Pacific was frequent. As an immediate aid, drying equipment by baking and then spraying it with varnish, shellac, lacquer or oil was tried. Though drastic in many instances, this usually restored the equipment to operative condition, which suggested that apparatus already completed or in the process of manufacture be similarly treated.

Extensive studies were initiated by Bell Telephone Laboratories, in coöperation with the U. S. Signal Corps, to determine the most satisfactory moisture barriers for insulating materials. Results showed that waxes were the best barriers but engineering and manufacturing requirements made preferable the use of a short-oil phenolic-resin varnish. Alkyd resin varnishes were also

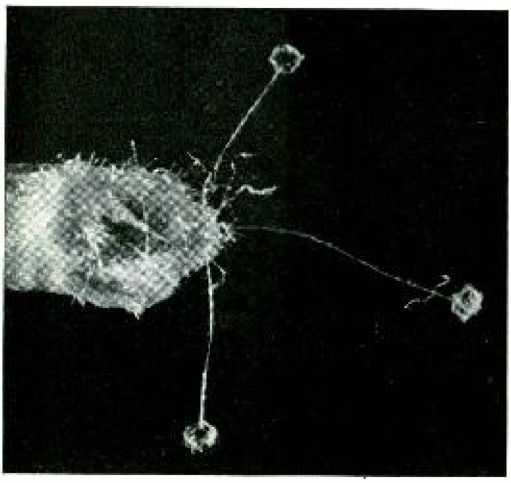


Fig. 1—Fungus growth on cotton insulation at the end of a wire

fairly satisfactory, but lacquers gave rather poor protection. The benefits derived from these treatments were evaluated and the possibility of deleterious effects were thoroughly explored. Recognizing that they were immediate remedies, however, steps were taken to provide better moisture-resisting materials for insulating wires and terminals. The design of apparatus, especially for use in the tropics, also claimed a large part of the Laboratories' effort. This work included investigations of hermetic sealing.

Another factor given considerable attention was the effect on insulation of fungus growths. It had long been known, through the Laboratories' studies on wood preservation, that cellulose and other materials of biological origin readily support fungi, because they are fungus foods. The web-like networks of these minute plants, shown growing on the surfaces of apparatus in the accompanying illustrations, are often spectacular in appearance. Reports from the field, however, have tended to overemphasize the trouble caused by them. Figure 1 illustrates how fungus may grow on the cotton insulation at the end of a wire. Figure 2 is an enlarged view of a terminal block removed from a radio set after it had been in storage for two months. The web-like fungus plants extend up the sides of the barrier and bridge the adjacent punching in the terminal block. In Figure 3 is shown a similar comparison of a section of a block of phenol plastic before and after exposure to fungi in the laboratory. From these pictures it can be readily understood why attention was directed to the fungus while the insidious effects of the invisible moisture, condensed and absorbed on the surfaces and in the materials, were at first underestimated. Until the relative importance of these factors could be evaluated, more reliance was sometimes placed on fungicidal coatings, sprayed on apparatus, than was justified. Fungus growths are most effectively controlled by impregnating, with a fungicide, organic materials which are good food for these organisms or by substituting other materials less easily attacked.

Selection of a suitable fungicide is at best a compromise arrived at by considering many factors. It must be effective in preventing the growth of lower forms of plant life and yet innocuous to personnel during manufacture and subsequent use. The fungicidal properties must be maintained for the life of the equipment or material protected. Therefore it must be relatively insoluble in water, for certain service conditions, or stable to heat when used in equipments which run warm during operation. Deleteri-

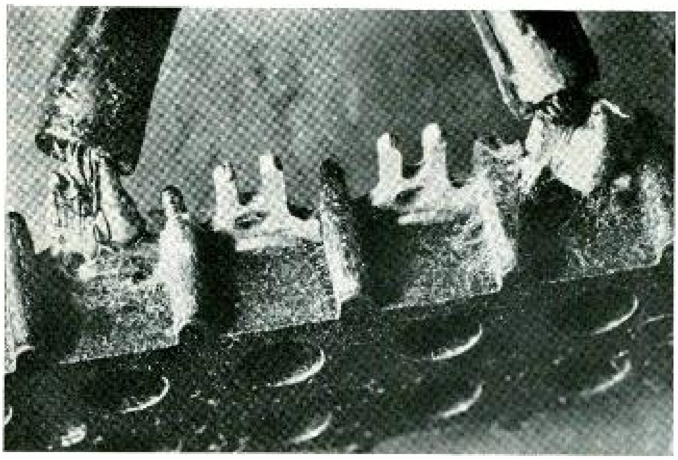


Fig. 2—Enlarged view of a terminal block from a radio set. It is covered with fungus growth after storage for two months in the tropics

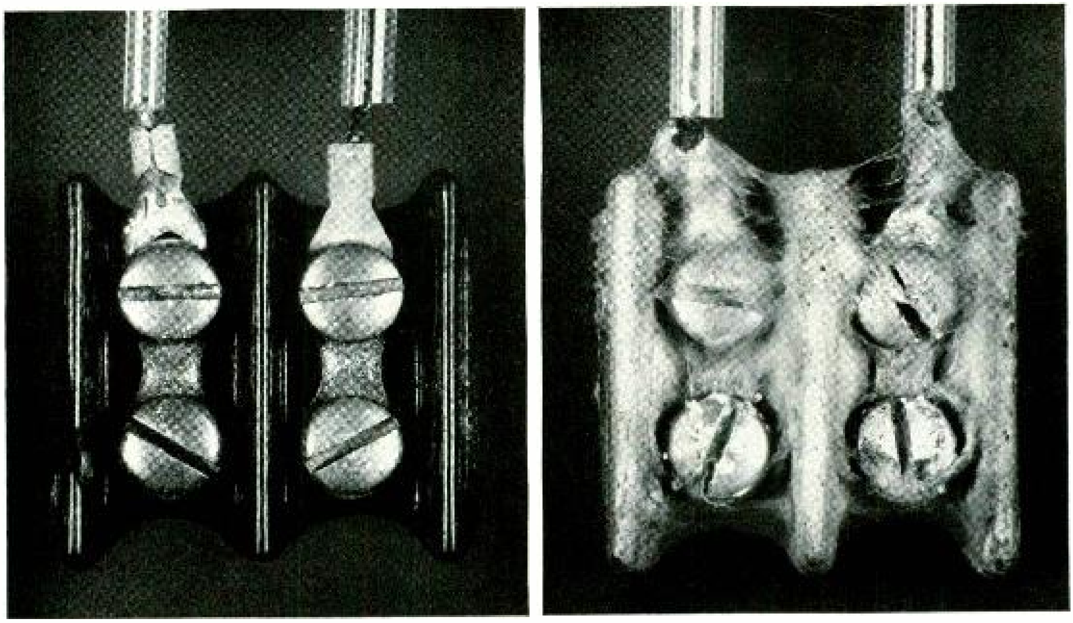


Fig. 3—Section of a phenol plastic block before and after exposure to fungi in the laboratory

ous effects on adjacent materials must be guarded against. Studies of fungicides showed that one class of compounds, the organic mercurials, adversely affect selenium rectifiers, others corrode metals and several have bad effects on electrical properties. After selecting a fungicide on the basis of physical, chemical and biological behavior, availability and cost, methods of application call for considerable study and development. Specified treatment must be practical within the limits of available manufacturing facilities. Close control over manufacturing processes, through chemical analysis, is also an important adjunct to satisfactory fungus-proofing of materials.

The overall spraying of apparatus with fungicidal varnishes has helped as an emergency measure to keep much military equipment in operative condition in the field. Its use will soon be restricted, however, to critical parts of circuits because equipment will be engineered to avoid the injurious effects of moisture and fungus growths.

The information given in this article is based on the coöperative efforts of the members of the Moisture and Fungus Proofing Committee of Bell Telephone Laboratories. The findings of this committee have been included in a report which has received wide circulation and is being used extensively by organizations designing equipment for tropical use.

THE AUTHOR: JOHN LEUTRITZ, JR., joined the Laboratories in the fall of 1929 after graduating from Bowdoin College with the B.S. degree in chemistry. He worked on rubber problems for a few months and then began biological research on wood preservation. Continuing his studies at Columbia University, Mr. Leutritz received an M.A. degree in botany in 1934 and has recently submitted his thesis there for the Ph.D. War projects have for some time diverted his attention largely from his various investigations of wood preservation problems.

Report of Employees' Benefit Committee

THE purpose of the "Plan for Employees' Pensions, Disability Benefits and Death Benefits" is to provide payment of definite amounts to employees when they are retired from service, disabled by accident or sickness or, in the event of death, to their dependent beneficiaries. The Plan is administered by the Employees' Benefit Committee under the Chairmanship of R. L. Jones. The other members of the Committee are A. B. Clark, M. J. Kelly, D. A. Quarles and G. B. Thomas, and E. W. Adams, J. W. Farrell and W. Fondiller serve as alternate members. J. S. Edwards is Secretary of the Committee, and K. M. Weeks is Assistant Secretary. The following is a report of operations of the Committee for the year 1944.

Retirements and Deaths

During the year, twenty-eight members of the Laboratories retired from active service, eight under the Retirement Age Rule, seven at their own request, and thirteen because of disability. At the close of the year there were one hundred and fifty-five employees receiving service pensions, seventeen disability pensions, and three special pensions.

Thirty deaths occurred during the year, of which eight were retired members of the Laboratories and five were employees on military leave of absence. Where eligibility to death benefits existed, payments to qualified beneficiaries were authorized as provided in the Plan.

Accidents

As has been noted during the last five years, the incidence of accidents during the course of employment at the Laboratories continues to rise. During 1944, however, the number of cases per one hundred employees increased only six per cent over the previous year as compared with a fifty-one per cent increase in 1943. The total number of accidental injuries was two hundred and sixty-six, one hundred and thirty-two of which involved lost time of one or more days. However, as an offset to this lessening acceleration of accident incidence in 1944 was

Statement of Benefit Payments for the Year 1944

Under the "Plan for Employees' Pensions, Disability Benefits and Death Benefits" the following benefit payments were made during the year 1944:

Payments by Trustee from Pension Trust Fund:	
Service Pensions	$286,668.28
Payments by the Company:	
Disability Pensions	10,113.17
Payments after Death of Pensioners	14,904.48
Accident Benefits and Related Expenses	27,374.50
Sickness Disability Benefits	202,186.14
Sickness Death Benefits	63,467.59
Total Benefit Payments	$604,714.16

Status of Pension Trust Fund

As reported by the Bankers Trust Company, Trustee, the status of the Pension Trust Fund was as follows:

Balance in Fund, December 31, 1943		$13,190,256.43
Additions to Fund during 1944:		
Payments into Fund by Company	2,169,778.00	
Interest Revenue, including gain or loss on investments disposed of	429,917.30	
Disbursements for Pensions during 1944	286,668.28	
Net Increase in Fund		2,313,027.02
Balance in Fund, December 31, 1944		$15,503,283.45

an increase of sixty-two per cent in working days lost per one hundred man-days of work over the preceding year. Further analysis discloses that thirteen accidents accounted for sixty per cent of the time lost.

Sickness Disability

Aside from service pension payments, sickness disability benefits constituted the largest single item of expenditure under the Plan. Contrary to the general trend which has been noted among other companies of the Bell System and other industries, the number of cases of sickness per one hundred employees decreased twenty-two per cent in 1944 as compared with 1943 and, more significantly, there was an eight per cent decrease in working time lost per one hundred man-days of work. There was also a downward trend in working time lost in sickness not under the Plan. The payments for sickness not under the Plan were charged to departmental expense and cover absences of less than one week's duration or for first week absences of benefit cases and for absence of those with insufficient service to be eligible to sickness benefits. Sickness payments under the Plan decreased eleven per cent per $1,000 of Payroll while sickness payments charged to departmental expense decreased sixteen per cent. Departmental sickness payments were eighty per cent higher than those charged to the Plan.

Supplementary payments and special pensions amounting to $19,051 were paid to forty active employees, three beneficiaries of deceased employees and ten retired members of the Laboratories in need of special assistance during the year.

Leaves of Absence

Leave-of-absence activity still continued at a high level during the past year; five hundred and forty-one leaves were granted and three hundred and sixteen were terminated. As of December 31, 1944, there were one thousand and fifty leaves outstanding, eight hundred and ninety-three or eight-five per cent of which were granted for military service. Of the balance, sixteen were for Merchant Marine service, twenty-seven to engage in war work in a civilian capacity with Government or allied agencies, ninety-eight for personal reasons, and sixteen because of disability. Aside from those employees who died in the services, eighteen military leaves were terminated during 1944. The qualifications of those who were discharged from the services and who applied for reinstatement in the Laboratories were evaluated to take into consideration experience and training gained while on military leave, and the employee was offered reinstatement in at least his former or equivalent position and at a rate of pay equal to what he would have received if he had remained at the Laboratories in his former position.

(Signed) J. S. Edwards, *Secretary*
Employees' Benefit Committee.

March Service Anniversaries of Members of the Laboratories

10 years

Blanche Adams
Stephen Balashek
Paul Reiche

15 years

J. C. Bayles
M. D. Brill
A. B. Conner
R. V. Crawford
D. W. Farnsworth
C. S. Fuller
W. M. Kellogg
R. H. Klie
J. L. Lindner
Maude Marks
Annesley Megraw
F. W. Metzger
W. C. Michal
T. J. Montigel
James Morrell
Nelius Murphy
R. C. Newhouse
A. E. Pattinson
R. L. Robbins
V. E. Rosene
A. H. Schafer
G. W. Schaible
A. K. Smith
K. D. Smith
D. H. Wenny, Jr.

20 years

Gustav Bittrich
C. A. Charity
Alice King
John Leitl
Mary Mallard
Anna Moses
G. C. Otterbein
C. E. Pollard, Jr.
E. Rampone
B. F. Runyon
J. A. Sherwin
Anne Sweeney
Virginia Trahey

25 years

F. J. Aimutis
W. W. Andrews
Valerie Beers
Hattie Bodenstein
C. T. Boyles
A. A. Carrier
G. C. De Coutouly
K. M. Fetzer
Fred Gebhardt
R. E. Hartwig
R. S. Hawkins
W. J. Heitsmith
J. B. Hennessy
J. M. Holahan
H. G. Jordan
Mary Joyce
R. L. Lunsford
R. J. Miller
W. A. Moore
John Oetzman
W. A. Schroeder
F. F. Siebert
M. N. Smalley
E. A. Wieland

30 years

R. A. Clarke
G. G. Muller

35 years

Edward Greenn
A. G. Hall

40 years

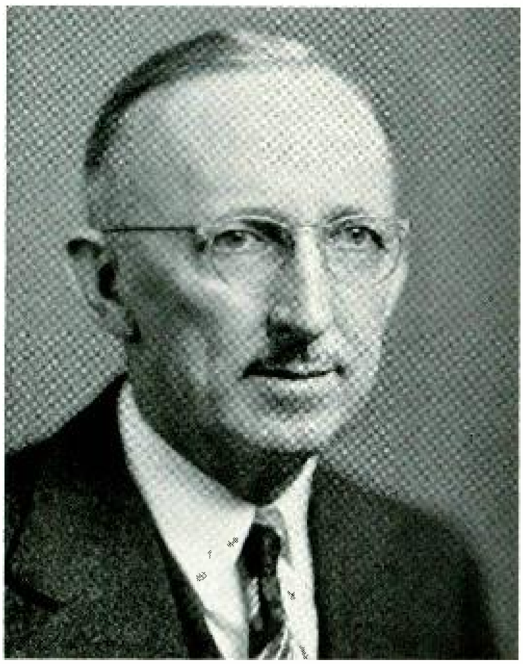
F. J. Scudder

The Chemical Laboratories

THE CHEMICAL Laboratories had its beginning in a small group of chemists who supplied the elementary needs of chemical analysis to engineers at a time when fewer materials were required in telephone apparatus. As research led to new developments, it became necessary to provide chemical consultation and service in an increasingly broader field of materials.

Specialists in metals, rubber, paper, wood preservatives finishes, ceramics, plastics—indeed nearly all of the materials of commerce—came into the Department and have found stimulating opportunities to practice their specialties in satisfying the needs of expanding developments. Research undertaken in these fields has contributed new products of uniquely useful properties and provided background information for the solution of engineering problems. The availability of many new materials from recent developments in chemistry and metallurgy, the improvements in fabrication and the trend toward mechanization of manufacture present a new industrial era which, if the Laboratories is to profit from it fully, will require the close association of chemical and metallurgical research and materials engineering.

In this way, modern materials and technological advances can be adapted and applied to the needs of the research development and design organizations. The recent consolidation within the Chemical Laboratories of a group of engineers formerly in the Materials Standard Department should greatly assist in the realization of this objective. Upon the reorganized Chemical Lab-



R. M. Burns, Assistant Chemical Director, has been appointed Chemical Director, reporting to the Director of Research. In this capacity Dr. Burns will be in charge of the Chemical Laboratories

To permit R. R. Williams, Chemical Director, to devote more of his time to matters of national interest in the field of nutrition, he has been appointed Chemical Consultant, reporting to the Director of Research oratories falls the responsibility of selecting the diverse materials required in the development of the intricate apparatus and equipment of the telephone plant. This responsibility will be exercised effectively by close collaboration with electrical and mechanical engineers in the early stages of design.

The selection of materials for engineering purposes is but one aspect of the work of the enlarged Chemical Laboratories. It will be necessary for this group to define the level of quality desired in these materials, to develop suitable tests and testing procedures for the establishment of this quality and finally to embody these in specifications, the use of which will provide assurance that the materials will meet the requirements of service.

J. R. Townsend has been appointed Apparatus Materials Engineer, reporting to the Chemical Director

Fundamental research will be continued in chemistry and metallurgy for the purpose of increasing our basic knowledge of the relationship between the composition and structure of materials and their properties and behavior in telephone applications. Problems of aging, corrosion and degradation which are the results of reactions with elements of the surrounding environment must be understood in order to be controlled. Our unique interests in the behavior of materials in electrical fields which depends upon such things as molecular constitution, atomic configuration and electronic energy distribution has led to programs of fruitful research. A relatively simple chemical compound has often found a multiplicity of uses as apparatus and circuit elements. As the telephone system has grown in complexity, it has become increasingly necessary to carry on exploratory and engineering studies in the whole materials field in order that we may be in a position to request of outside industries the kinds of chemical compounds or alloys having the highly specific properties which are required. As the trend toward new developments continues in the post-war period, so also will the need of new and better things from chemistry and metallurgy.

Frank B. Jewett Fellowship

Five Frank B. Jewett Fellowships for research in the physical sciences have been awarded to Dr. Elliot R. Alexander, Dr. Albert S. Eisenstein, Dr. Kenneth Greisen, Dr. Boris Leaf, and Dr. Harry Pollard. The availability of these men to accept their fellowships will depend upon the progress of the war, as each is now engaged in essential war research.

Founded by the American Telephone and Telegraph Company, the fellowships are in honor of Frank B. Jewett, a Vice-President of that company and Chairman of the Board of Bell Telephone Laboratories, who retired in 1944. Each fellowship is for one year, and carries a stipend of $3,000, with a further honorarium to the institution where the work is done. Primary criteria are: Demonstrated research ability of the applicant, the fundamental importance of the problem he proposes to attack, and the likelihood of his growth as a scientist.

Dr. Alexander received his Ph.D. from Columbia in 1944 in organic chemistry. He is presently a research chemist at the duPont Experimental Station at Wilmington.

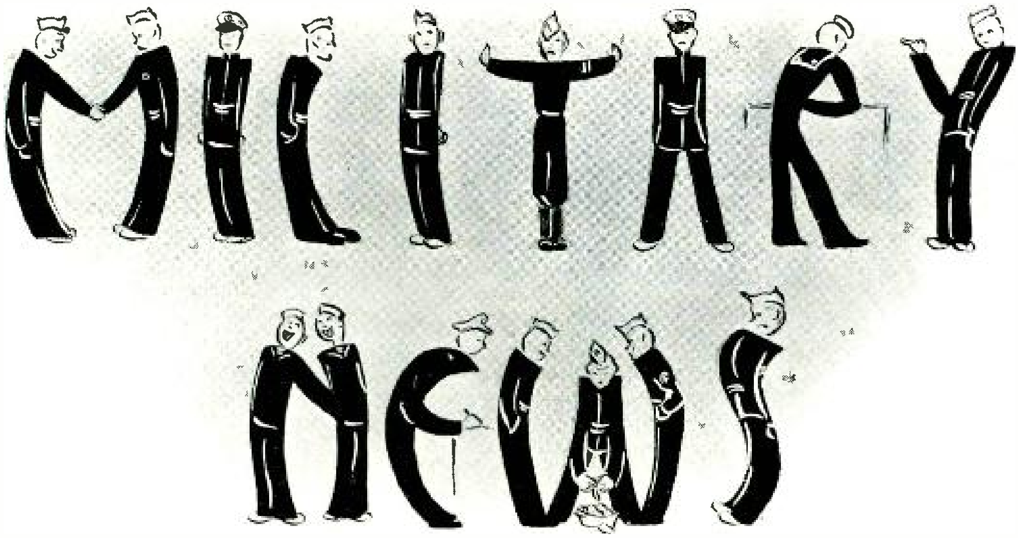
Dr. Eisenstein received his Ph.D. from the University of Missouri in 1942 in physical chemistry. He is at present a member of the Radiation Laboratory staff at Cambridge, Mass.

Dr. Greisen received his Ph.D. from Cornell in 1943 in physics and mathematics. At present he is engaged in war work at Santa Fe, N. M.

Dr. Leaf received his Ph.D. from the University of Illinois in 1942 in physical chemistry. He is now an associate chemist in the Metallurgical Laboratory of the University of Chicago.

Dr. Pollard received his Ph.D. from Harvard in 1942 in mathematics. Now he is a member of the Applied Mathematics Group at Columbia University.

The Committee of Award, which consisted of mathematicians, physicists and chemists of Bell Telephone Laboratories, considered a total of 41 applications from which the five above were selected.



Lieut. Robert F. Healy

Additional information has been received about Lieut. Robert F. Healy, who was reported missing in action over the English Channel since November 5, 1944, indicating that he was the pilot of a P-47 (Thunderbolt) fighter plane which departed from England on a combat mission to Frankfurt, Germany, on that day. The report reveals "that during this mission en route from the target at about 2:10 P.M., east of Orfordness, England, over the English Channel, a radio message was received from him stating that he was going to bail out as his plane was having difficulty. No further contact was made by Lieut. Healy with other members of the flight. . . . A continuing search by land, sea, and air is being made to discover the whereabouts of all missing personnel. As our Armies advance over enemy-occupied territory, special troops are assigned to this task, and agencies of our Government and Allies frequently send in details which aid in securing additional information."

Lieut. Alfred Bertin

"I am writing from a hospital bed. I was just getting over the burns that I received when our plane cracked up when I contracted malaria. Right now I am feeling a lot better but still am rather weak. I am in the Moluccas Islands with my permanent squadron which is part of the 13th Air Force. I can truthfully say that this is the nicest spot that I have been in since being overseas. The squadron I am in is part of a heavy bombardment group. My job is to navigate the plane wherever it may go. It is quite interesting work."

William M. Flushing

"I've been spending most of my time as a mortar gunner with the 78th Division in Germany. They say this is the worst winter Germany has had in a long time. After spending the coldest part in a foxhole I agree. I saw combat before going to the hospital where I am now. I am being sent back to the U. S. and hope to be on my way soon."

Capt. Einar Reinberg

"The organization is still the same except that I am now Battalion S-3 after commanding a front line company for 46 days' straight running. During our stay here of a bit over four months we have had a worm's-eye view of France, Alsace Lorraine, Germany, Belgium and Luxembourg from foxhole to foxhole. Personally I've been extremely lucky thus far and can boast a Purple Heart for a nick in the lip, a Bronze Star and a Battle Star for the battle of Germany. Incidentally, the 104th Infantry Regiment is one of the few units which censorship regulations permit mention of with the 3rd Army.

"GI Joe is slugging it out with the best Germany has to offer and is now maneuvering for a knockout blow."

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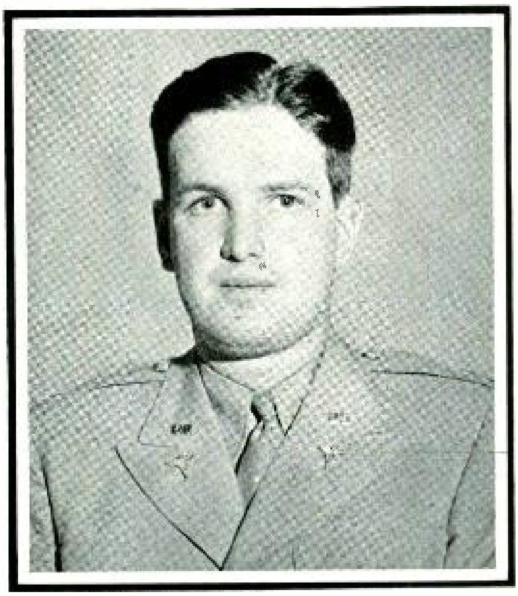
Captain O. F. Crankshaw Killed in Action

Word was received from the War Department by his wife that Captain Orrin F. Crankshaw was killed in action in Germany on February 23, 1945. Captain Crankshaw, who was attending physician for the Laboratories at Murray Hill before his military leave of absence, was in the Medical Corps of the Sixth Armored Division. Before going to Europe he had been in the South Pacific and had participated in the battle of Guadalcanal. As noted in the last issue of the RECORD, he had recently received the Bronze Star Medal for meritorious achievement in connection with military operations in France during the period from July 28 to October 10, 1944. He also received the Purple Heart in January after he was wounded when the jeep he was riding in struck a German mine. The citation said he continued his duties despite the severe injuries he suffered.



Capt. Orrin F. Crankshaw, 1910-1945

Captain Crankshaw, after attending Lyndhurst and Rutherford Schools, received his A.B. degree in Chemistry and Zoölogy from Dartmouth in 1932. He continued there in the Medical School and then transferred to the Cornell Medical College in 1933, from which he received his M.D. degree in 1935. Following one and one-half years of interneship and two and one-half years as a resident in internal medicine at New Haven Hospital, along with post-graduate studies at the Yale Medical School, he began to practice medicine in Summit. He was on the staff of the Overlook Hospital in Summit and was attending physician at the Murray Hill Laboratories from February 2, 1942, to July 15, 1942, when he was given a military leave of absence to serve with the Yale Medical Unit.

Edward B. Gempler

"These months in the Pacific have seen me in many places. The censorship regulations have been lightened so now I may tell you about some of the places that I've seen and about my personal experiences.

"As it happens I'm the only radio technician aboard this destroyer escort. This is a big job for one man as it means that the upkeep, maintenance and knowledge of each piece of electronic equipment is entirely up to him. Some of the most important types of equipment that I am in charge of have been originated at the Laboratories. In fact, while I worked in the model shop, I helped make parts which are identical to those found in this equipment.

"After leaving the States we had a thrilling trip through the Panama Canal and spent a few days in Panama. From there we stopped off at Galapagos Island, Bora Bora and the New Hebrides. I had some very interesting experiences at Tulagi, Florida Island, Guadalcanal, Bougainville, Rossel Island, Vella Lavella, Treasury Island, Manus and Los Negros in the Admiralty group. The islands are exactly as they have been described in your newspapers.

"As I am not permitted to mention military missions or actions, I shall just mention the place. The first white women that I saw out here were the Wacs in Hollandia, New Guinea. I guess the most interesting time and the closest that I've come to civilization was while we were at Leyte in the Philippines. I got over to the city of Toclobon and picked up some souvenirs and received a bird's-eye view of how the people have lived through their two years of captivity. There was no liberty for the men because of the fighting going on there."

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Clinton A. Jaycox

"At present I am with Company HQ as acting communication sergeant and we are living in a Jerry house complete with livestock, chickens and provisions. With all this and the ingenuity of the GI, life is easy, but we are reminded every so often by Jerry that a war is still going on. Only this morning they threw in a barrage of about thirty shells, with this house (which, standing alone, is an excellent O.P.—and Jerry knows it) as the target. There were no casualties, but the scramble for the cellar was a lulu!

"I see that Herman Manke is flying a P-61 night fighter. We see, or rather hear, many of these planes here along with German night fighters. At first it is hard to tell the difference, but you learn. One of the worst feelings to have is to be in a crowded vehicle in a blacked-out convoy and have a Jerry night fighter looking for you. On the occasion I'm thinking of, traffic was at a standstill and the plane flew slowly back and forth across the road, once giving a burst of M.G. I'm glad nobody shot at him because that is all he would have needed to spot the road for sure."

Charles M. Voss

"I am now in Germany and have visited Holland and Belgium. The Dutch are very friendly, and I was pleasantly surprised to hear almost all of them saying 'Hello' in very good English. Since then, I have learned that the children are taught English in school. Holland is very beautiful and very clean. Their bar rooms and restaurants are spotless. I have seen man-made dikes and people living in houseboats which appeared to be very comfortable. So far I haven't seen a single windmill. All the homes are modernistic and similar to homes in the U. S."

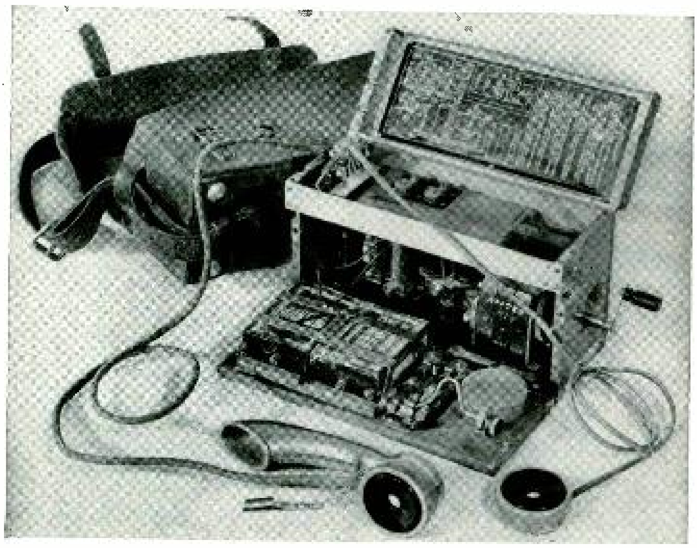
Richard C. Fiala

Richard C. Fiala of the Fourth Marine Division has been sent back to the States for training at Yale University and then at Officers' Candidate School. He took part in the campaigns of the Marshall Islands, and Saipan and Tinian of the Marianas Islands. His division has received the Presidential Citation. He had been overseas since July 1942. He brought back with him a Japanese field telephone set which he picked up during the battle on Saipan last August. He has presented this to the Historical Museum.

Robert Schuster

"The trip across the pond was an experience in itself. I didn't get seasick, and for entertainment I read books, listened to a band composed of men of the Armed Forces (good musicians), and watched the water and the other boats of the convoy. After landing in Europe I went through France in the 40 and 8 cars; they must have been from the last World War—they were as old as that. I've been in France, Belgium, and now in Holland. I did pass through Aachen, Germany, and that town is certainly well destroyed; buildings are a mass of ruins, and those standing are roofless and floorless.

"There isn't much I can tell you about the war because of various reasons. There is something I will quote from *Yank* magazine that is intended for all people of America: 'We soldiers in combat feel that if the war workers knew the true situation here, we wouldn't have to worry about production.



Japanese field telephone set picked up by Richard C. Fiala during the battle for Saipan

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Roll of Honor

Killed in Action

Lieutenant Ernest G. Graf
Ensign David F. Greenhagen
Private Sarkis Karibian
Private Edward A. Fern
Lieutenant Stanley W. Erickson
Captain Orrin F. Crankshaw
Private Harry A. Malone, Jr.

Missing in Action

Lieutenant Robert F. Healy
Private Joseph T. Murphy
Lieutenant Everett Urbanski
Lieutenant Thomas M. Pepe

Prisoner of War

Lieutenant Ralph D. Horne

Leaves of Absence

As of February 28, there had been 952 military leaves of absence granted to members of the Laboratories. Of these, 51 have been completed. The 901 active leaves were divided as follows:

Army 512 **Navy 290** **Marines 30**
Women's Services 69

There were also 18 members on merchant marine leaves and 24 members on personal leaves for war work.

Recent Leaves

United States Army

Charles W. Deming, Joseph D. Mead, Joseph J. Doyle, Frederick G. Ruppenstein, William N. Leufer, Raymond A. Schroder

United States Navy

Elizabeth E. Doyle, Joseph A. Pecon, Jr., Charles F. Weiss

Merchant Marine

William C. Prendergast

It is about time we quit feeding ourselves all this propaganda and got down to facts. Until recently the average man in the States thought the war was practically over. It is impossible for us to see an end to this. Censorship prohibits the GI from giving a true picture. That great country of ours wasn't founded on lies and we don't believe it will progress on them in times like these. We are not worried over post-war plans or the GI Bill of Rights. We want to get back to the United States and be civilians again, and speak to people whom we can understand.

"'That sizes up what ninety per cent of the GI's think and know. America is where we belong and we would like to be there and see that it stays free, independent, and truthful. The people over here are nice, they appreciate what the American soldiers have done, but they aren't like American people.'"

Lieut. Robert I. Nolan

"For the past few months I've been assigned to an Infantry Division here in France. For a time we were in Germany but since then there have been some changes made. It is pretty cold here right now and the snow is getting deeper each day. But there sure could be a lot worse places to be."

Harold Phares

"The Island of Corsica is mostly mountainous and the tops are covered with snow now but the weather is pretty mild. The island is covered with dense brush, cork trees, sheep, goats, rocks, and Corsicans. Out behind the camp area are the ruins of things that were built centuries ago. Most of the natives here live just as their ancestors did hundreds of years ago. Homes, walls, fences, stables and anything else they wish to build is built with rocks. I think that all they've done for the past 500 years is pile rocks. There are modernized cities on the coast populated mostly by native French.

"I flew as radio operator in the States but now I fly as radio operator, waist gunner and photographer. Taking pictures of the proceedings is very interesting and takes your mind off the flak, but I usually freeze my hands. The pictures are taken through a hatch in the bottom of the ship."

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Robert A. Dryden

"At present we are living in an orchard and the neighboring fields are the depot. If one steps off the boardwalk he goes into mud up to his hips. For the past few months I have been working with our Special Service Officer. We have a theater which I manage, and I operate one of our 16-mm machines. We have been very fortunate to receive shows which just reach the public back home. The theater seats about 300 people and each row of seats is elevated above the preceding one. We have a stage which is 20 feet long and 13 feet in depth. On each side are dressing rooms for stage performers. Aside from the USO shows we have put on one of our own and at present are making plans for a quiz show. I also have to maintain our company library which consists of the leading magazines and pocket-size books—we have approximately 200. All the fellows in the outfit contribute their own magazines when finished. One fellow gives his *Bell Ringer* and I contribute the Record."

Martin C. Nielson

"This new home of ours is in the Marianas Islands. It is very hot here. There are still some bombing raids and also a few Japs. The great sport of the island is to go out Jap-hunting in the uninhabited parts. During our trip here we stopped at the Hawaiian Islands and were impressed by the sights—Waikiki Beach, Diamond Head Mountain, Nuuanu Pali, and the city of Honolulu."

Richard E. Strebel

"I graduated from primary school on November 10 and left for Navy Pier, Chicago. I was assigned to the Educational Office Drafting Department and worked for a lieutenant on preparation and drafting of Navy schematics and wiring diagrams. I worked there for a whole month and then, at my own request, I started my secondary school. The theory and laboratory work are divided about 50 per cent each. The laboratories are well equipped with test equipment and various types of hush-hush gear. Every type of gear is set up for actual operation and it is amazing to see what this apparatus can do. Bell Lab designed and Western Electric built equipment are rated high."

John J. Mosko

"I am well and enjoying the tour of Belgium, considering the circumstances. I wondered, as I passed the Labs, how many were watching us sail downstream. I saw plenty of evidence of the Signal Corps here, including lots of Spiral-4 cable. It made me a little homesick."

Colonel Albert J. Engelberg

"I am here at Wright Field temporarily on a special assignment for the Air Technical Service Command. I am slated to make a tour of the United States visiting the fourteen area ATSC's and the six procurement districts. My work will be to instruct Air Communications Officers in the latest practices relative to the integration of former Signal Corps functions into the Army Air Forces. Briefly, we have taken away control of all fixed communications from the numbered Service Commands and there are a lot of details to iron out."

Ensign John P. Manning

Ensign John P. Manning of the Navy Air Corps returned to visit West Street recently. Ensign Manning has been overseas in the South Pacific since May, 1944, as an SB-2C Curtiss Helldiver pilot. He took part

"He sort of adopted me while I was stationed down in the South Pacific"

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in raids over the Admiralty Islands, and in the pre-invasion raids over the Philippines. He has returned for further training at the Naval Air Station at Vero Beach, Florida.

Nelson A. Popp

"Completing my gunnery course in Oklahoma, I was sent here to Florida for 'Operational' training. Everything that I learned about aviation radio and gunnery would have been combined with actual flying. We were to be trained in the Navy SBD 'Dauntless,' as 'rear-seat' radio-gunners. In fact, training was begun and I got in quite a bit of flight time. Then an order came through from Washington converting this to a fighter base. Since there is no room aboard a fighter for an aircrewman (that's me), I expect to be shipped out. Our course

Daniel T. Hayes   Henry Widmann

is to be continued in another type of aircraft. While awaiting orders I am, more or less, part of the ground crew. It's my job to help gas planes."

Vincent Decker

"I have been on active duty in the Navy for the last six months aboard a destroyer escort operating in both the Atlantic and the Pacific. While in the European theater we saw such interesting places as Gibraltar, Oran, Algiers, Messina, Sicily and Italy. We are now somewhere in the Pacific at anchor off an island which you no doubt have been reading a lot about in your daily papers. The natives are very friendly at these islands and usually come out to our ship in their boats to sell us things they make. There is quite an array of grass skirts and shell necklaces on board and some of them are very pretty."

Maj. L. W. Stammerjohn   Lt. H. E. Manke

Joseph F. Daly

"While taking a course in AAFTAC in Orlando, I had the opportunity to hear about some of the things the Laboratories are doing for the Air Forces and I'm looking forward to the Record's technical description.

"Speaking of the Labs creations, I've been instructing a course at the school on the latest lightweight radar. It does a wonderful job for the tactical purpose. Personally, I hope to assist in removing the bugs which crop up."

Henry Widmann

Henry Widmann, radio technician on a submarine, returned to visit West Street after a year's active duty in the Pacific. He is back on a thirty-day leave after seeing action in many of the campaigns in the Pacific.

Lieut. Herman E. Manke

Lieut. Herman E. Manke, a "Black Widow" P-61 fighter pilot, has returned to this country after sixteen months' active duty in the Air Forces in the Pacific. Lieut. Manke has completed fifty-three missions with 300 hours of combat flying and was awarded the Air Medal with one Oak Leaf Cluster. He expects to be assigned to duty in the States after he reports to Atlantic City for reassignment.

Major L. W. Stammerjohn

Major L. W. Stammerjohn returned to visit West Street recently after three and one-half years of overseas duty in the Signal Corps assigned to the 9th Air Force. He spent two years in Iceland, some time in England, and then went to France last

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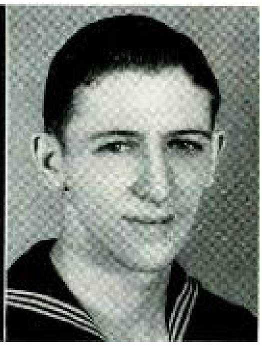


ARTHUR C. LUEBKE
Sampson, N. Y.

EDWARD F. ANSTEDT
Key West, Fla.

August. He traveled through most of northern France and Belgium.

In England Major Stammerjohn met A. B. Clark and D. K. Martin of the Laboratories while they were visiting the European war theater.

He has returned to this country to attend a Signal Corps School in Florida.

Walter A. Farnham

"Lately I've been in Hawaii on rest leave. Came back here a little before Christmas after being up there for Thanksgiving. I had the pleasure of going to a cattle ranch for four days while there. Seemed good to be in a home again. Our hosts went out and caught some wild turkeys, so we had all the trimmings. We had a chance to get caught up on our eating—by that I mean fresh foods and milk. It may seem strange, but when you haven't had them for a while, they sure seem good."

* * * * *

RECENT PROMOTIONS of members of the Laboratories: Lt. (jg) William L. French; Edward A. Hake, RT 3/c; Anthony A. Luciano, BM 2/c; Colonel Morton Sultzer; Lt. (sg) David F. Tuttle, Jr.; Pfc. William J. Behan; Louis A. Bergdahl, RT 2/c; Robert M. Eichhorn, S 1/c; William R. Frees, RM 2/c; S/Sgt. Ellis Gilliam; S/Sgt. Armin J. McNaughton; Marie J. Marti, Y 3/c; T/5 Harry J. Stewart; William P. Weiler, SF 1/c; Pfc. Robert H. Meuser; Richard C. Bogstahl, Jr., EM 2/c; 1st Lt. David E. Brenneman; Cpl. Thomas J. Comparetta; Lt. (jg) Donald S. Duguid; A. T. Frederick H. Engelman; Sgt. Grace M. Goodall; Thomas Johnson, RM 3/c; S/Sgt. James B. Kennedy; Raymond J. Martin, AMM 2/c; 2nd Lt. Edward J. Zillian; Herbert E. Henrikson, F 1/c.

AN ITEM in the last issue referred to R. S. BAILEY as a Major. Since the time he received the Legion of Merit award he has been promoted to Lieutenant Colonel.

CARL W. BACHMANN is with an anti-tank company in France; C. H. MATTHEWS of the Seabees is in the Admiralty Islands; ANTHONY A. LUCIANO has been assigned to an LST in the Pacific.

ALBERT C. REYNELL is studying carrier equipment at Camp Crowder, Missouri; ENSIGN CLAUDE A. MCJOHNSTON is stationed at Mare Island, California; FRANK R. SANTASIER is attending electrician's school at the Detroit Naval Base; HOWARD J. ROHR is stationed at Norfolk, Virginia.

EDWARD F. ANSTEDT, son of PHILIP ANSTEDT of the Murray Hill Shipping Department, was a Utility Service Hand at Murray Hill from the time of his graduation last summer from the Bernardsville, New Jersey, High School until he joined the Navy in November. Edward had boot training at the U. S. Naval Training Station at Sampson, New York. He is now a Seaman 2/c receiving advanced training at Key West, Florida.

PHILIP A. WALZ has been transferred to Camp Howze, Texas; WALTER SOKOLOSKY is stationed at Bradley Field, Connecticut.

WAYNE F. WILSON writes: "Our General Hospital has set up here in Paris. I am, at present, a member of the MP detachment. I've seen most of the buildings, monuments and statues, and, though they are impressive, I'll still take Rockefeller Center."

WALTER R. SCHLEICHER is "fighting the

JOSEPH E. SILEO
Turner Field, Ga.

ROBERT J. CAMERON
Camp Croft, S. C.

war in the biggest marble-lined foxhole in the world—the Pentagon Building in Washington. I'm working in the War Department Signal Center with multi-channel radio telegraph equipment designed by BTL."

JOSEPH H. HILL has completed his first week of secondary school here in Chicago. "Our days begin at 6:00 A.M. and end about 5:30 P.M. It seems quite long, but the week went very quickly. I estimate that we have to walk three miles a day just for chow alone—it is really a big place."

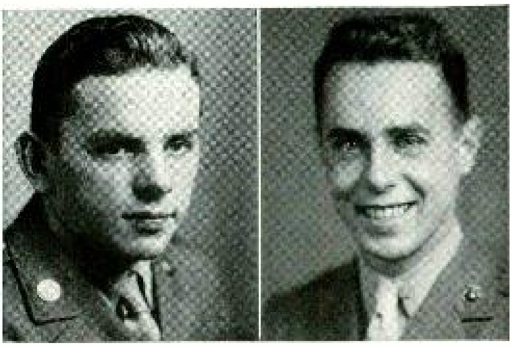
LIEUT. LAURENCE G. FITZSIMMONS, Jr., writes: "The work here at the post-graduate school at Annapolis is still most interesting and I feel that I am learning much that will be of value both to the Navy and later on with the telephone industry. In about two more months I expect to go out there again and continue that war against the Japanese."

CAPT. GEORGE M. RICHARDS, as Section Navigator with one of the Training Sections on his base at Tonopah, Nevada, helps train and send out about sixty combat crew navigators in B-24 bombers every few months.

"THE SOUTH PACIFIC lure has finally caught up with me," says WILLIAM FREES. "I left California in November and have been to Noumea, Guadalcanal and Bougainville. I cannot mention where I am now for obvious reasons."

The tropics, according to WARREN GOLDSTEIN, are a great place—to be far away from. "The heat is almost unbearable and the thousands of different insects really get under your skin. Of course, I can overlook the daily rain."

WILLIAM H. OLPP is "Somewhere in Alsace—France—experiencing various types of warfare and battle procedures. So far have remained in good health and shape despite continued hazards for quite some time. Actual battle experiences and methods of maintaining communications are naturally strictly censored—so can say little in regard to such items."



WILLIAM H. SCHEER Camp Croft, S. C. — RICHARD C. FIALA Yale University

H. E. HENRICKSON Norfolk, Va. — JOSEPH C. LANG Sampson, N. Y.

CHARLES F. MOORE visited West Street after completing his boot training at Sampson, New York. He expects to be sent to San Diego.

MARIE KEOUGH of the Waves visited the Laboratories before leaving for her new assignment to an air base in Hawaii. Two girls are selected each month to be sent to Hawaii from the Great Lakes Naval Training Station where she had been stationed.

LIEUT. WARREN B. SAGE visited West Street on a recent leave from the San Marcos Army Air Base in Texas. He received his commission there as a navigator, and expects to be sent overseas shortly.

DAVID WEBSTER visited here while on leave from McCook, Nebraska. He is a tail gunner on a B-29, and expects to be sent overseas.

JOHN E. CRONIN has been assigned as a radio operator to a Field Artillery Battalion of a Headquarters Battery somewhere in Belgium.

EDWARD SCHOLLMEYER, formerly a member of the Laboratories at Murray Hill, is on duty on the carrier U.S.S. *Wasp*. "Everything has been going along fine out here. We have been to many places and participated in many historical events. I have seen quite a lot of W.E. equipment on board and I'm learning to maintain it."

Word has been received that FREDERICK B. MONELL is now a Major.

Robert Schuster, John P. Robinson, A. J. McNaughton, D. F. Cuneo, and William J. Behan have been sent overseas.

Robert J. Cameron and William H. Scheer visited the Laboratories recently on furlough from Camp Croft, South Carolina.

Gloria Carstensen of the Spars is stationed at Long Beach, California; Grace Goodall of the Wac has been transferred to the Pratt Army Air Field in Kansas.

Herbert E. Henrickson of the Navy has completed secondary school and expects to be assigned to active duty shortly; Arthur C. Luebke has completed his boot training at Sampson, New York. He will return there after his leave for reassignment.

Eunice E. Storey, Wac, is doing airborne radar maintenance work at the Army Air Forces Proving Ground Command, Eglin Field, Florida.

H. W. Menzel writes: "Just got back from a furlough in Australia during which I had the good fortune to run into Ed Fischer of the Labs, who is also doing communications work out here. We enjoy the Record when it reaches us—it's like a letter from home."

Richard C. Bogstahl is on a destroyer escort in the Atlantic; Lieut. D. S. Duguid of the Submarine Service returned to visit West Street on a recent leave after two years of active duty; R. J. Martin is also on active duty in the Pacific.

Charles Hempel writes: "Out here in the Pacific one can seen the fine work the Labs are turning out."

James V. Cunningham visited the Laboratories recently. He has been on active duty as an electrician on a submarine for fifteen months, both in the Atlantic and the Pacific.

Jack Roback is with the First Marine Division in the Pacific.

Lieut. Glen S. Bishop of the Marine Corps visited the Laboratories recently. He has been stationed at Ft. Monmouth, New Jersey, studying carrier, teletypewriter, and telephone equipment. He expects to be transferred to California.

Edward J. Buckley is with the Seabees in the South Pacific; Joseph P. Delano is in France; Lieut. Thomas B. Horton is with the Army Air Forces in Europe.

Flight Officer William V. Hoshowsky was formerly a single engine pilot but has been transferred to take a course to become a Flight Engineer on a B-29.

Joseph Mazzi of the Navy is "somewhere in the Marianas"; Lieut. Edward J. Filipovits has recently been sent overseas.

News Notes

By amendment of the By-Laws of Bell Telephone Laboratories, Incorporated, effective March 7, 1945, the organization title of General Auditor was changed to Comptroller. As Comptroller, A. O. Jehle continues to have the same responsibilities and to exercise the same authority as previously vested in him as General Auditor.

R. L. Jones attended a meeting of the Non-Ferrous Metallurgical Advisory Board of the Army Ordnance Department which was held at Frankford Arsenal, Philadelphia.

During the Months of December, January and February the United States Patent Office Issued Patents on Applications Previously Filed by the Following Members of the Laboratories

L. G. Abraham	E. P. Felch, Jr.	A. E. Joel, Jr.	D. Mitchell	C. F. Spahn, Jr.
H. A. Affel	O. A. Friend	E. H. Jones	O. J. Murphy	G. R. Stibitz
W. M. Bacon (2)	C. S. Fuller	C. S. Knowlton	N. D. Newby (2)	F. W. Stubner
H. L. Barney	R. B. Gibney	G. T. Kohman	J. E. Nielsen	B. S. Swezey
H. M. Bascom (2)	M. C. Goddard	F. A. Korn	K. W. Pfleger	R. L. Taylor
H. W. Bode	F. C. Griese	J. A. Krecek (3)	C. H. Prescott, Jr.	C. R. Walker
J. T. L. Brown	R. O. Grisdale	F. B. Llewellyn (2)	H. M. Pruden	J. G. Walsh
M. S. Burgess	L. N. Hampton	C. W. Lucek	R. B. Shanck (3)	E. F. Watson
S. I. Cory (2)	G. Hecht	J. J. Mahoney, Jr.	A. H. Shangle	G. W. Willard
F. R. Dennis	R. B. Hearn	R. F. Mallina	O. A. Shann	S. B. Williams
G. H. Duhnkrack	A. D. Hulbert	M. B. McDavitt	G. C. Southworth	L. A. Wooten
P. G. Edwards				

F. R. LACK, formerly of the Laboratories and now vice-president of the Western Electric Company, has been elected a member of the Board of Directors of the American Standards Association.

DURING THE WEEK of March 19, the sound pictures *Introduction to Radar* and *The War Speeds Up* were shown to members of the Laboratories in the West Street auditorium. Later they were shown at the Davis building and at Murray Hill, Whippany, Holmdel and Deal. *Introduction to Radar* outlines the principles of radar and illustrates the uses to which the equipment is put. *The War Speeds Up* depicts the dependence of our soldiers upon "the Big Four"—artillery, bombs, trucks and tires—and how these and other essential material are now required in even greater quantities than ever before.

One of the five forty-foot elm trees in front of the restaurant at Murray Hill died last fall and has been replaced. The new tree, with its roots embedded in soil and carefully protected with burlap, was delivered on a low-slung trailer. It was skidded into place with a power winch

ACKNOWLEDGING a copy of the RECORD containing the article *Electrical Director Helps Bring Down Buzz-Bombs* sent to him by K. K. DARROW, Sir George P. Thomson of the Imperial College of Science and Technology in London said: "I saw quite a lot of the work of your predictors while I was in the Air Ministry and they certainly made a big difference to the success of the campaign against the V-1 bombs."

"Talking Books for the Blind" has just recorded JOHN MILLS' latest book, "Electronics Today and Tomorrow." This is the second of his books to be made available to the blind, for "A Fugue in Cycles and Bels" was recorded several years ago.

THE UNION CLUB of New York and the Nassau Club of Princeton, N. J., were addressed during the month of March by Mr. Mills on the subject of *Electronics Today and Tomorrow.*

HARVEY FLETCHER has been appointed a member of the Advisory Board of the Research Council of Rutgers University.

J. N. SHIVE is serving as an Instructor in Physics in the evening courses at Rutgers University in connection with their War Training Program.

C. A. LOVELL spoke on *The Gun Director's Conquest of the Robot Bomb* before the Montreal Section of the I.R.E. on February 23 and before a joint meeting of the Royal Canadian Institute and the Toronto Section of the A.I.E.E. on February 24. He illustrated his talk by slides and by a sound film, *The V-1 Robot Bomb.* Earlier in the month Dr. Lovell presented the same talk before the Princeton Club and before the Western Electric Post of the American Legion.

B. L. CLARKE attended an N.D.R.C. committee meeting at Harvard University.

K. G. COMPTON and J. LEUTRITZ, JR., attended a meeting of the Committee on Electrical and Electronic Equipment of N.D.R.C.

"The Telephone Hour"

(NBC, Monday Nights, 9:00 P.M., Eastern War Time)

APRIL 9, 1945

April Showers — *Arranged*
Orchestra

Bright Phoebus — *Hook*
Marian Anderson

Un sospiro — *Liszt*
Orchestra

My Lord, What a Morning — *Spiritual-arr. Burleigh*
Wake Up, Jacob — *Spiritual-arr. White*
Marian Anderson

Street Parade and Bareback Riders from "Circus Day" — *Taylor*
Orchestra

Humble fille des champs from "Charles the Sixth" — *Halévy*
Marian Anderson

APRIL 16, 1945

Concerto in C—First Movement — *Kreisler (after Vivaldi)*
The Old Refrain — *Kreisler*
Liebesfreud — *Kreisler*
Liebesleid — *Kreisler*
Schön Rosmarin — *Kreisler*
Caprice Viennois — *Kreisler*
Fritz Kreisler and Orchestra

APRIL 23, 1945

Molly on the Shore — *Grainger*
Orchestra

Menuet from "Sonatine" — *Ravel*
Sardana — *Casadesus*
Robert Casadesus

Voices of Spring — *Strauss*
Orchestra

Concerto No. 23 in A Major, K. 488—Finale — *Mozart*
Robert Casadesus and Orchestra

APRIL 30, 1945

Si, tra i ceppi from "Berenice" — *Händel*
Ezio Pinza

Clair de lune from "Suite Bergamasque" — *Debussy*
Orchestra

Into the Night — *Edwards*
Cato's Advice — *Huhn*
Ezio Pinza

Feria (Festival) from "Rapsodie espagnole" — *Ravel*
Orchestra

Madamina, il catalogo from "Don Giovanni" — *Mozart*
Ezio Pinza

Bell Laboratories' Club has no more tickets for these programs because its limited supply has already been distributed to applicants.

held at Washington on February 21 for the purpose of stressing the importance of problems in connection with tropicalization.

C. H. Sample, on March 1, attended a meeting of Advisory Committee B-8 of the A.S.T.M. and, on March 3, the Research Committee of the American Electroplaters' Society in Pittsburgh.

G. W. Willard discussed quartz crystals before the Science Club of the Scotch Plains (N. J.) High School.

C. A. Webber and W. J. King were at Wright Field and Hawthorne on high-voltage cable and connector problems.

R. M. C. Greenidge visited the Ucinite Corporation in Washington on matters connected with crystal unit containers.

L. C. Tilloston discussed problems connected with the manufacture of filters at the Point Breeze plant.

A. J. Grossman and T. R. Finch, at the Naval Research Laboratory, Washington, discussed delay networks and filters.

N. Insley visited Sperti, Inc., Cincinnati, on matters pertaining to glass seal terminals.

E. B. Ferrell spoke on *The Servo Problem as a Transmission Problem* at the USO Club, Red Bank, at a meeting sponsored by The Institute of Radio Engineers.

At the Hawthorne plant of the Western Electric Company, D. R. Brobst and T. L. Tanner discussed precision resistance networks; L. F. Koerner, the adjustment of special crystal test sets; E. B. Wood, magnet wire, hook-up wire and switchboard lamps; R. G. McCurdy, W. L. Casper and R. A. Sykes, quartz crystals; and P. S. Darnell, resistor problems.

R. T. Staples, at the Baltimore and Scranton plants of the Western Electric Company, discussed cord problems.

A. J. Christopher, at the Aerovox Corporation, New Bedford, Mass., and the Hawthorne and 47th Street plants of the Western Electric Company, Chicago, discussed capacitors.

A. G. Ganz, T. H. Chegwidden, P. P. Cioffi, A. J. Christopher and J. A. Ash-

WORTH visited the Pittsfield plant of the General Electric Company to confer on magnetic materials.

S. J. ZAMMATARO observed the performance of special testing apparatus at the Naval Research Laboratory in Washington.

J. R. WEEKS was at M.I.T. in connection with moisture-proofing of silvered-mica button-type capacitors.

E. C. HAGEMANN went to Haverhill to discuss the scheduling and production of retardation coils; L. W. MORGAN, also at Haverhill, discussed transformers.

P. S. DARNELL and A. H. SCHAFER were at the International Resistance Company in Philadelphia on resistor problems.

DURING THE month of February, R. R. MACGREGOR visited several manufacturers in connection with moisture-proofing problems on power transformers.

G. D. EDWARDS participated in a Quality Control Clinic sponsored by The Quality Control Engineers of Rochester which is affiliated with the Industrial Management Council of Rochester. Mr. Edwards addressed the dinner meeting of the Clinic, his subject being *The Future of Quality Control.*

H. F. DODGE demonstrated the operation of *Double Sampling Inspection Procedures* at a New York conference of chief inspectors of the Chemical Warfare Service.

C. J. CANCIK visited the Thomas B. Gibbs Company, Delavan, Wisc.; John Oster Manufacturing Company, Racine, Wisc.; and the Warner Swazey Company, Cleveland, where he discussed motors.

Please put your RECORD in the "Correspondence-Out" box when you are through with it so that it can be sent to a Serviceman's family.

J. R. PIERCE, on March 21, presented the fifth lecture of the *Electron Ballistics Symposium* being conducted by the Basic Science Group of the A.I.E.E., New York Section. He spoke on *Physical Limitation in Electron Ballistics*.

J. G. PETKUS visited the plant of the Heywood-Wakefield Company at Gardner, Mass., to discuss special equipment.

F. A. WAHLE, on a trip to Providence, R. I., discussed manufacturing problems with engineers of the Taft Pearce Company.

V. T. CALLAHAN assisted in the installation of a cooling system for a gasoline engine at the New England Telephone and Telegraph Company in Boston.

R. H. ROSS discussed improvements for dynamotors at the Gray Manufacturing Company, Hartford.

E. D. SUNDE, D. W. BODLE, J. J. MAHONEY, and D. G. NEUMAN have been in Georgia conducting surge tests on the new lightning-protected cable being installed between Atlanta, Ga., and Meridian, Miss.

G. Q. LUMSDEN visited Charlottesville, Va., and Bedford, Pa., in connection with the development of oak insulator pins.

F. D. LEAMER addressed the members of the Summit Rotary Club at their March 12 luncheon meeting on the subject *Evolving Employer-Employee Relationships*.

F. L. HUNT, at a meeting of the Morris County Engineers' Club held in Dover, N. J., on February 20, talked on the Murray Hill Laboratory.

A. R. THOMPSON, in a recent issue of *Publishers' Weekly* under the title of *Current Textbook Design*, discussed the changes that the production of textbooks in wartime has undergone.

Mary Lindner, 1866-1945

MARY LINDNER, formerly a technical assistant of what is now the Transmission Apparatus Development Department, who retired in 1927 after twenty-seven years of service, died on February 19.

Women of the

PHYLLIS JORDAN's work at Murray Hill includes keeping records of time cards, pay receipts, giving out keys, typing and general staff clerical work. She has been with the Laboratories over two years.

Her home is in Summit, where she combines work, patriotism, and fun in several wartime activities. Phyllis has been a Nurse's Aide at Overlook Hospital for two years. With a group of girls from the local YWCA she attends dances for the servicemen at Camp Kilmer once or twice a week. She has donated blood to the American Red Cross Blood Bank four times.

Some of her evenings are spent at Camp Kilmer as a Nurse's Aide in the hospital where wounded men just returned from the front are brought before being sent to hospitals near their homes. She is on duty from 4:00 to 9:00 in the evening.

BETTY LANG does general accounting work at the Laboratories' new location in the Telephone Building at 18th Street. This work includes various kinds of accounting, such as helping to make up expense reports for executive control. Betty came to West Street directly from high school three years ago as a mail girl, and was later transferred to the Accounting Department to work on Government cost analysis.

Betty is a hostess at the Music Box Servicemen's Canteen on Fifth Avenue, where she goes every week to entertain, dance, play games, or just talk with the servicemen. She enjoys reading and the movies and likes an occasional workout in the swimming pool or badminton court at the YWCA which is near her home in Ridgewood, Long Island.

Laboratories

Vivian J. Alling is working on relay computers being developed by the Systems Development Department for various research laboratories of the Armed Forces. She is responsible for feeding complicated problems to those robot mathematicians and renders the necessary assistance when the human touch is needed. In between times Miss Alling is showing visitors how the computer performs difficult problems. But she is always very careful to avoid technicalities and this is probably one of the reasons why she has larger audiences than the engineers when they are demonstrating the computer.

When Vivian came to the Laboratories she went to the technical assistants' classes at Fourteenth Street. She likes horseback riding, playing the piano and mystery novels, but her main interest is in New Guinea, with a lieutenant in the Signal Corps.

Florence Mowbray is a technical assistant in the Chemical Laboratories at Murray Hill. She is doing work in a specialized branch of the chemistry of high polymers—the casting of polymerizable resins. These materials, which are similar to some of the now familiar plastics, find many applications in war work.

Florence took up chemistry at the College of Saint Elizabeth in Convent, New Jersey. She enjoys playing bridge, dancing, bowling, swimming, tennis and golf. She teaches swimming at the Summit YMCA to some of the members of the Laboratories. As a member of the AWVS in Morristown, she helps to entertain soldiers who are stationed nearby. In addition to her other activities, Miss Mowbray is interested in Girl Scout work, and once had her own Scout troop.

Margaret Sweeney of the Commercial Products Development Department takes care of the distribution of newly issued specifications to the engineers or to the various manufacturing houses of Western Electric Company. These specifications cover the manufacturing information for all apparatus. She came to the Laboratories four years ago, and is now located in the Graybar-Varick building.

Margaret Sweeney

Two evenings each week Margaret works as a Volunteer Aide at the New York Foundling Hospital. Because of the shortage of nurses, these aides are urgently needed. They help wash and feed the children, prepare them for bed, and perform other duties for the children to relieve the nurses. Margaret has two brothers in service—one in the Army in the South Pacific and one in the Navy. Her sister, Catherine, is in the Personnel Department at West Street.

* * * * *

A recent addition to the Laboratories is Gloria Brooks, who enters High Frequency Transmission Engineering as the first woman to graduate in Electrical Engineering at Columbia, and who is the first woman to be elected a member of Tau Beta Pi, honor society in engineering. Acting Dean James K. Finck rated her top of her class. No mere academic prodigy, Miss Brooks combines active sports with a genuine interest in differential equations. In addition to her other activities, she is very fond of music. She plays the piano—has studied it for ten years.

Visiting Wounded Servicemen

Most women today are interested in doing what they can to help make life a bit more pleasant for our wounded servicemen who have been returned to hospitals in the United States.

Many of the girls have become Red Cross Nurse's Aides, but for those whose time is more limited, going to hospitals to visit with the patients has become the answer. Under the leadership of Janet Marceau, a member of the Laboratories, a group of girls entertains and visits with some of our recuperating veterans just back from the European front. The girls take refreshments and organize entertainment and games. There is no glamour in this kind of work, and it can be very discouraging. The boys don't want pity. They resent personal questioning about their disabilities. They also resent obvious forced efforts to cheer them. The girls don't go with the idea of attending a big party with lots of laughs. They want to try to dispel the monotony, the tension or the lack of self-assurance which often affects a man recovering from wounds or battle fatigue. But the boys are not necessarily grim or morose. Many of the girls come away from the hospital feeling that they have been cheered by the fellows as well as the reverse being true, and with a satisfaction in the knowledge that they have tried to help the boys who have come home. They are grateful for this opportunity.

Gloria Brooks

Joan Thomas, whose selection for this column made the photographer's work easy, helps the war effort by doing secretarial and stenographic work for J. F. Kearns in the Commercial Relations Department at Whippany. She started her work in the Laboratories' transcription group at West Street in June, 1941. In succession she was transferred to the Stenographic Department and then to the Commercial Relations Department, coming to Whippany in May, 1942.

Joan lives in East Orange, New Jersey. She is a graduate of Drake's Secretarial College in Orange. Her mother is a nurse in the Laboratories' Medical Department at West Street. Joan sings in her church choir, is fond of swimming, most summer sports and dancing, and is especially partial to the Navy. She is interested in art—likes to draw—and is eager to take some art courses as soon as free time becomes available.

Joan Thomas

* * * * *

Phyllis Nimmo is secretary to W. A. MacNair, D. E. Woolridge, and A. W. Horton, Jr., at the Murray Hill Laboratories. She attended Katherine Gibbs Secretarial School, and came to the Laboratories directly after completing her courses there.

Most of Phyllis' free time is taken up by her Nurse's Aide work. She has been a Nurse's Aide at the Overlook Hospital in Summit for over a year. She was recently selected to be one of the girls to do this type work at the hospital at Camp Kilmer where wounded servicemen are received from the European fronts.

Phyllis Nimmo

Phyllis also belongs to the Summit USO, and attends dances for servicemen at Camp Kilmer. She likes sports—swimming and horseback riding are her favorites.

Engagements

*Ens. James H. Riley, U.S.M.S.—*Kathleen Davey
Raymond W. Griffin, U. S. Navy—*Anna De Turo
*A. L. Williams—*Cecily Forrest
Walter Glock, U. S. Army—*Shirley Koenig
Clifford R. Dorsey, U. S. Navy—*Ann Ribachuk

Weddings

*Lieut. Herman E. Manke, U. S. Army—Lynette Fehleisen
*Ens. Lawrence A. Vabulas, U. S. Navy—Priscilla Foster
James Nelson—*Karin Lundin
*Robert G. McCoy—Joan Powell
*Lieut. Lawrence G. Fitzsimmons, Jr., U. S. Navy—Jane Smith

*Members of the Laboratories. Notices of engagements and weddings should be given to Miss Mary Ellen Wertz, Room 1103, Extension 296.

Victory Gardens

Last year home gardeners raised more than 40 per cent of all the vegetables grown in America. The Government is asking you to do as well again this summer. There are plenty of good reasons for gardening. First off—you'll save money. Even a small garden can produce from $25 to $50 worth of vegetables. Second—your health and your family's health should benefit. Third—you'll be helping to win the war. If you would like free information about gardening, the Government suggests that you write to your state agricultural college, or to Victory Gardens, Washington 25, D. C. The West Street library also has pamphlets that may be obtained upon request.

Fire Alarm System at Murray Hill

The fire alarm system at Murray Hill is operated by the expansion, caused by a rapid rise in temperature, of air in loops of small copper tubing located at the ceiling on the underside of the floor beams. Both ends of these loops terminate, at the alarm boxes, in a diaphragm. When the air pressure in the loop increases about an ounce and a half, these diaphragms expand and close an electric circuit that starts a coded signal. An adjustable air leak at the diaphragms compensates for slow changes of room temperature and prevents false alarms.

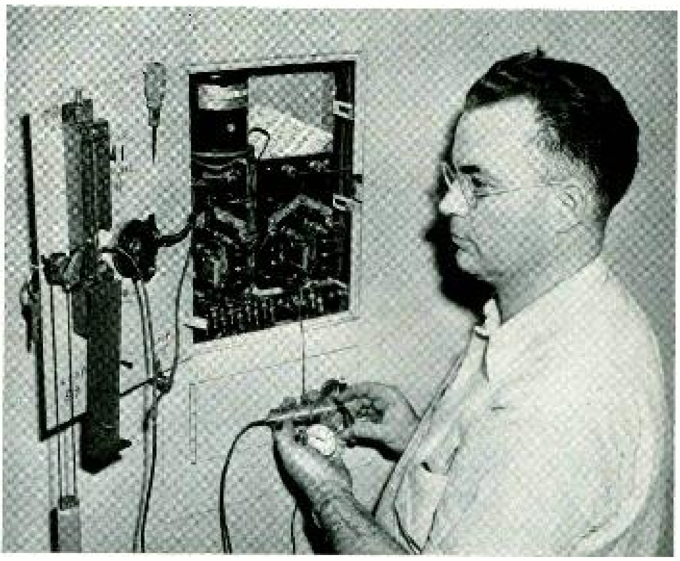
There are ninety-one of these loops, which vary in length from seven hundred to one thousand feet, and all of them are tested every month. In the accompanying illustration, H. W. Tillman is shown pumping air into one of the loops to check the pressure required to trip the alarm and to test for accidental leaks by observing how long it takes the pressure to decrease.

The Bell Telephone System Through the Years

Thomas Woodlock, of the *Wall Street Journal*, in his column "Thinking It Over" recently said:

"Reading over the report of the Bell Telephone organization issued last week, this writer wonders whether the present generation can appreciate the magnitude of the achievement of the telephone industry in this country in the short space of a single man's lifetime of three-score and ten years. Here was something wholly new in human experience, a completely novel service with no precedents to guide its development. Its 'economics' presented unusual problems for which there was no previous experience to serve as guide, particularly that of switchboard depreciation and obsolescence, which wrecked so many enterprises in competition with Bell.

"The demand for service once started grew with mushroom rapidity; the chart-lines of instrument numbers through the years approach the vertical formation. Yet the demand was met; the industry's managers had foreseen it and provided for it. It is true to say that at no time in its history, not even in World War I, did service ever notably fail to carry its load. Finally, as remarkable a feat as any, the Bell enter-



H. W. Tillman checks the pressure on the fire alarm system at Murray Hill prise has avoided the financial blunders that have so deeply spotted American corporate history and has so far proved as solid an investment for the ordinary small capitalist as can be found in the record here or anywhere. Last year it earned a net return on invested capital (unwatered) after expenses and taxes of 5½ per cent, which cannot reasonably be regarded as an unreasonable equivalent for service rendered.

"One way to view the 'worth' of that service is to suppose a purely hypothetical question. Let us imagine that to an enemy of the United States were given the power for twenty-four hours to paralyze a single 'public service' in the country by merely pressing a button or turning a switch—how could he most effectively disintegrate the whole social process? We have three main public services — transportation, power and telephone. Which would he choose and why? It seems to this writer that he would wisely select the telephone service.

"It penetrates the life of the community more deeply at more points and more continuously than does any other. There are over 21 millions of telephone instruments in the country. The total number of 'calls' made daily on the Bell System is approximately one hundred and ten million. Nor should it be forgotten that whoever has an instrument at his disposal can talk to the ends of the earth, if need should arise, without moving from his chair. There is not a single relation of man which is not the subject of telephone calls throughout the day. Suppose this service suddenly stopped without notice; only those who lived a third of their lives before it came into being can visualize the resultant on the country's life. What then is the 'worth' of the service to the customer; to be measured against the cost of the service to him?

"The present writer has seen in his day the advent of electric power and, if not the advent of the railroad, at least its emergence from 'teen age to adult maturity, and, of course, all the later scientific marvels: motors, movies, radios and the like. But somehow the telephone can give him still something of its first thrills."

U. S. Signal Corps Photo

Clarence G. Stoll, president of Western Electric Company, photographed during his visit to the Western Front in Europe to view military operations, particularly from the standpoint of the huge supply problem of the armies in that theater. Mr. Stoll's "Battle Front Report" was distributed to all members of the Laboratories

Naval Operations and Telephones

In a recent landing operation against a Jap-held stronghold in the Pacific, our Navy used 700 to 800 warships equipped with 48,166 telephones, according to Navy Department estimates. These shipboard telephones were connected by some 5,000,000 feet of telephone cable of various sizes.

The 48,166 telephones involved in that one naval operation are equal to the number serving a city about the size of Flint, Michigan, or Youngstown, Ohio.

Here is dramatic evidence of the vast quantities of communications equipment required to wage global war. It assumes even greater proportions when the single operation is multiplied many times over by equally large naval units in action on both sides of the globe. Added to the Navy's requirements are the tremendous communications needs of the Army's ground and air forces and of stationary installations around the world.

TELEPHONES AND TELEPHONE CABLES FOR VARIOUS TYPES OF WARSHIPS

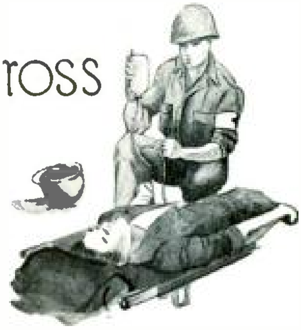
	Number of Telephones	*Feet of Cable*
Battleship—Iowa Class	1,556	155,600
Carrier—Essex Class	1,358	135,800
Light Cruiser—Cleveland Class	902	90,200
Destroyer—Fletcher Class	230	23,000
Destroyer Escort	169	16,900
Attack Transport	200	20,000
Landing Ship Tank	63	6,300
Landing Ship Medium	32	3,200
Landing Craft Infantry—Large	11	1,100
Motor Torpedo Boat	10	1,000

To telephone people the Navy figures help to answer the question of why telephone facilities are scarce on the home front. They indicate something of the additional amounts of equipment which will be required by our Armed Forces before the war against Japan is finally won.

U. S. Navy Photo

White foam swirls across the decks of a Navy battleship of the "Iowa" class as a task force moves across the Pacific on a war mission at the close of 1944. In the background are other ships of the force, including an "Essex" class carrier at the left

Red Cross Blood Donors



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Appointments for blood donations may be made with the American Red Cross Blood Donor Service, 2 East 37th Street, Telephone, Murray Hill 5-6400. The offices are open from 10:30 A.M. to 8:00 P.M., Mondays through Fridays, and from 10:30 A.M. to 4:00 P.M. on Saturdays.

To compute the number of telephones and the amount of cable involved in the landing operation, the Navy used the figures for the various types of warships given in the accompanying table.

General Ingles Lauds Bell System Committee

Bell System Headquarters, March 2—After working with Army and Navy officers to save the Government an estimated $7,000,000 a year on toll and teletypewriter services, a Bell System committee won praise from Maj. Gen. H. C. Ingles, Chief Signal Officer of the United States Army, on completion of its mission early this year. The committee was formed in November, 1942, at the request of Maj. Gen. Frank E. Stoner, Chief of the Army Communications Service.

Myron F. Dull, now at the head of a group for new and special services in the Operations and Engineering Department of the American Telephone and Telegraph Company, was named chairman. Committee members were Roy S. Breese, Russell J. Anspach, and Richard W. Miller, Long Lines engineers, and Bruce E. Osgood, general sales supervisor of the Michigan Bell Telephone Company. [Consultants to the Committee were E. F. Watson, Teletypewriter Engineer, and C. A. Parker, now on leave in the War Department.—Ed.]

In a letter written to President Walter S. Gifford, General Ingles recalls that the purpose of the committee was to assist in making efficient use of communications facilities in the United States, and to develop plans for the overall improvement of military communications here.

The committee, General Ingles says, in his opinion was "the biggest single factor in the efficient organization of the Army's domestic communications facilities which are now operating on a highly efficient and satisfactory basis, notwithstanding the tremendous increase in traffic volumes.

"As a direct result of the committee's work, a great improvement has been effected in the service rendered, with large reductions in costs to the Government and resultant savings in equipment and line facilities."

While savings that resulted from the committee's work must be estimated in part, the following figures are derived from records on which results could be traced with accuracy:

$7,000,000 annual telephone charges now are being saved by the Government.

Over 52,000 miles of telephone and 32,000 miles of teletypewriter channels, representing some $1,600,000 of critical material investment, were conserved.

Over 100 full period leased line telephone circuits (upwards of 50,000 miles) urgently needed for use in the message toll plant are being turned back to the telephone company for night service.

2,800 critical teletypewriter items, representing a capital investment of roughly 2½ million dollars, were saved.

Microwave Radiation From the Sun

RADIATION from the sun has warmed and lighted the earth ever since there was an earth to be warmed. With the identification of light as a form of electromagnetic radiation, and of so-called heat radiation as similar but at a slightly lower frequency, there has been interest in the possibility of radiation from the sun at wavelengths widely removed from those that give rise to light and heat.

More than fifty years ago Professor S. P. Langley of the Smithsonian Institution measured the energy radiated from the sun over a band of wavelengths comprising light and extending a short way into the ultraviolet region and over a fairly wide range of frequencies in the infra-red region. Figure 1, traced from some of Langley's data, shows the energy spectrum he found after correcting for absorption in the earth's atmosphere. In the infra-red region, the curve extends to a wavelength of 2.5×10^{-4} centimeters, but Langley was supposed to have carried his measurement to wavelengths of 5.4×10^{-4} centimeters. Beyond this point the energy was apparently too small to be measured by methods then available. In the years that followed, Fowle, Abbot, and others at the Smithsonian Institution gradually edged this frontier forward. Others also joined in the drive, each in his turn scoring small but nevertheless important gains, one of the more recent being that of Adel of the Lowell Observatory, who in 1942 reported readings at 2.4×10^{-3} centimeters. During this period negative results had been reported by Nichols at 5×10^{-3} centimeters, and by Reber at 1.87 meters and by Jansky at 14.6 meters. More recently (1944) Reber has reported the actual observation of solar radiation at a wavelength of 1.87 meters.

As early as June, 1942, A. P. King and G. C. Southworth of the Holmdel Laboratory made measurements of solar radiation in the centimeter region, and observed levels in close agreement with theory. A year later, G. E. Mueller, also working with Southworth, extended the range to wavelengths both shorter and longer than those of the previous year. Together these covered very well the range between one and ten centimeters.

A double-detection receiver was employed, associated with a parabola so mounted that it could be directed to any part of the heavens. The very considerable noise inherent in the receiver appeared at all times, but when the parabola was directed at the sun, there was considerably more noise than was found with the parabola directed to any other part of the sky. This indicated that radiant energy was being received from the sun over bands of frequencies in the vicinity of the three wavelengths employed.

From theoretical considerations, it is possible to calculate the energy that would be radiated at different frequencies from a hot body such as the sun, and Langley's data conformed to such calculations over the range of his observations. Measurements of energy made in these recent tests were also found to be in approximate agreement with the calculated values. The agreements for the middle and longer wavelengths were very good, and although the energy at the shorter wavelength was quite appreciably below the calculated value, it was not be-

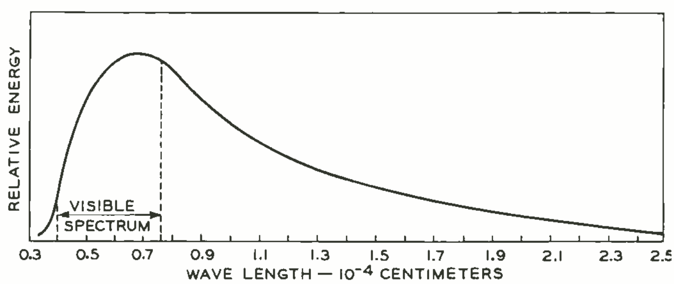


Fig. 1—Energy spectrum of radiation from the sun as measured by Langley

yond possible later justification.

There is thus now experimental evidence of the presence of radiation from the sun at wavelengths far longer than those of light—10,000 times as long as the longest wavelengths reported by Langley, and 1,000 times longer than those reported by Adel. The position of these various measurements on the electromagnetic frequency spectrum is shown in Figure 2, where frequency is plotted along the abscissa axis and wavelength along the ordinate axis.

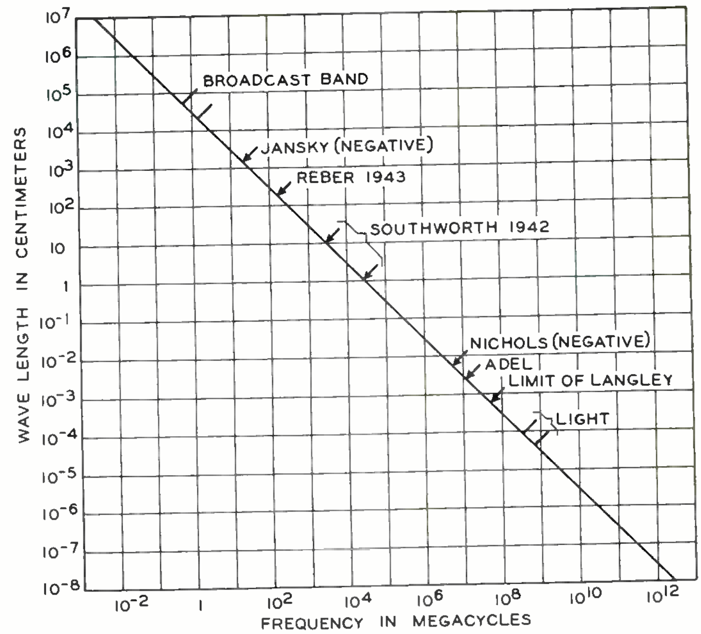


Fig. 2—Positions on radiation spectrum of sun of various measurements made

The calculated values of energy radiated from the sun referred to above are based on the commonly accepted radiation theory and assuming the sun to have a volume of 1.41×10^{33} cc and a temperature of 6,000 degrees K. If this is the true explanation of the short-wave energy received from the sun, energy in accordance with the same law of radiation should be obtained from other bodies. This was verified, qualitatively and partly quantitatively, by directing the receiver toward the open sky and nearby objects. There was considerably less noise from the open sky than from objects on the earth.

Other observations were made to determine possible absorption of the radiation by the earth's atmosphere, to study the manner in which the radiation increased and decreased as the sun was rising and setting, and to explore other characteristics. In addition to establishing the fact that radiation at these wavelengths is received from the sun, the most important indication of this work is perhaps that more extensive study should be undertaken, and to the extent that time and circumstance will permit, such studies are contemplated.

A full account of Dr. Southworth's studies of microwave radiation from the sun is appearing in the April issue of *The Journal of the Franklin Institute.*

"For Valor and Service"

It should not be necessary for anyone to ask a returned serviceman or woman where he or she saw service in this war. If they were in the Armed Forces prior to Pearl Harbor or have been outside the continental limits of the United States, they will be wearing one of four easily remembered service ribbons: the American Defense (pre-Pearl Harbor); Asiatic-Pacific; American Theater; and European-African-Middle East. Millions of our service people are eligible to wear one or more of these four ribbons, which are easily recognizable after a little study and practice.

In order to assist in instantly recognizing these service ribbons and those which designate the more common decorations or medals, a pamphlet entitled "For Valor and Service" has been distributed to all members of the Laboratories. If you failed to get a copy or would like additional ones, they are available at the West Street library.

Enemy Versus American Air Power

"THE design of enemy planes appears to be improving with each model. Compared with even a year ago, their aircraft have superior engines, improved accessories—and they're manufactured from first-class materials, with plenty of good steel and natural rubber." Thus spoke Col. John M. Hayward, Chief of the Technical Data Laboratory at the headquarters of the Air Technical Service Command, Wright Field, over the Columbia Broadcasting System during a recent "America in the Air" program. Col. Hayward, who is on military leave of absence from the Laboratories, continued:

"Nazi planes have always been designed for top performances, and there's no evidence that they're changing their minds. In spite of our heavy bombing attacks, their aviation factories, which are dispersed all over the country, keep plugging away. Just look at their new jet planes and robot bombs. They're of excellent quality and performance. You'd never judge from them that Hitler is bothered with material shortages or lack of manpower.

"On a recent trip to the Pacific war zones, I got a chance to study the Hamps and Zekes and some of the new Jap bombers at first hand. The Nips have been busy copying from American and German designs. But it's well to remember that they improve as they copy. And there is strong evidence that the Japanese have great reservoirs of manpower available for producing planes on a larger scale than ever before.

"Our testing and analyzing of enemy aircraft goes on every day in the laboratories at Wright Field. Working together with some 300 aviation manufacturers, we've been able to dig up a lot of information that helps in designing equipment which gives our fliers an edge in combat. But there's plenty to be done by Americans everywhere. The first thing for everybody to keep in mind is this—don't under-rate the enemy.

"From our analysis of enemy aircraft, we know they're ingenious and ambitious. They're determined to go on building faster and better war planes. We can't relax for a moment. Just remember, the designers, the engineers and the aircraft workers in Japan and Germany are working night and day, trying to outsmart and out-produce Americans in our aircraft industry. They have done a tremendous job already, but so have we. What's more, we have brains and the know-how to outstrip them. But we must give our hearts and souls to the task. We've got to stay on our jobs every hour of every day, until we've won the war on both sides of the world."

COLONEL JOHN M. HAYWARD

Self-Service Stockrooms

By R. H. WILSON
General Service Manager

SELF-SERVICE stockrooms, which have held a familiar place in Bell Telephone Laboratories during the last four years, are actually an innovation in the field of stockroom operation. These are the first large self-service stockrooms to be operated and successfully controlled in an industrial organization.

Since the self-service principle was adopted, it has proven its worth in economy of operation and service to the individual. That a saving of about $50,000 per year is realized speaks for itself. This is partly due to a considerable reduction in the number of stockkeepers necessary for efficient operation. There are many advantages, however, which are equally important but which cannot readily be evaluated.

The display of all stock frequently permits an item to be selected that is more suitable for the job in hand than the one originally sought, and it also facilitates substitutions when an item is temporarily out of stock. Still another feature is the almost complete elimination of waiting. One makes his choice, fills out his ticket, and is through without a period of waiting for those ahead of him to be served.

In spite of wartime demands that have increased the amount of stock handled to approximately $2,000,000 annually, the control exercised over the distribution of material is as efficient and successful as before self-service was introduced. This has also been the experience of the Massachusetts Institute of Technology, which in its Radiation

Laboratory has two large stockrooms of equal size, one operated on a window-service basis and the other fashioned from our method of self-service operation. In comparing one against the other they find that there are fewer stock discrepancies and smaller amounts of material withdrawn in their self-service stockroom.

All of the advantages gained under self-service operation can be summed up in the two words economy and service: economy which results in a saving of actual time and money, and service which enables one to secure quickly and completely the material that is necessary for the proper functioning of the Laboratories.

One of the window-service stockrooms still in use in the Laboratories

Effect of Common-Channel Interference on Frequency-Modulation Broadcasting

By A. L. DURKEE
Radio Research

MANY listeners to frequency-modulation broadcast programs have noticed a very curious effect that is not encountered in amplitude-modulation reception. While listening to a nearby FM station, they occasionally find the desired program blanked out completely for brief intervals by the program from a distant FM station operating on the same assigned frequency. This comes about as the result of abnormal conditions in the atmosphere which temporarily enhance transmission from the distant station and cause its carrier amplitude to exceed that of the desired station. However, to understand the sudden suppression of the desired program that takes place in the receiver under these circumstances, it is necessary to consider some of the fundamental characteristics of frequency-modulation systems.

An alternating current may be represented graphically by a rotating vector, as indicated in Figure 1. The length of the vector corresponds to the peak amplitude of the current, and its rate of rotation to the frequency. The projection of this vector on the horizontal axis gives the instantaneous value of the current. If the frequency of the current is constant, the vector rotates at a uniform rate, and the magnitude of its horizontal projection varies sinusoidally between maximum positive and negative values equal to the length of the vector.

Suppose, now, that the vector represents the carrier of an FM transmitter. If the transmitter is unmodulated, the vector rotates at a constant speed corresponding to the unmodulated carrier frequency. When a modulating signal is applied, however, the speed of rotation is caused to vary about the unmodulated value in accordance with the amplitude variations of the signal. To visualize the motion of the vector, it will be helpful to imagine that the constant component of the rotation, corresponding to the unmodulated carrier frequency, has been subtracted in Figure 1. Under these conditions the vector appears in some fixed position such as s when no modulating signal is applied to the transmitter. The effect of the modulating signal then is to swing the vector back and forth about s between two extreme positions such as s_1 and s_2.

A desired and an interfering carrier, both unmodulated, could be represented by the rotating vectors s and Q shown by solid lines in Figure 2. S is assumed to be considerably larger than Q. A radio receiver would respond to the resultant, R, of these two carriers.

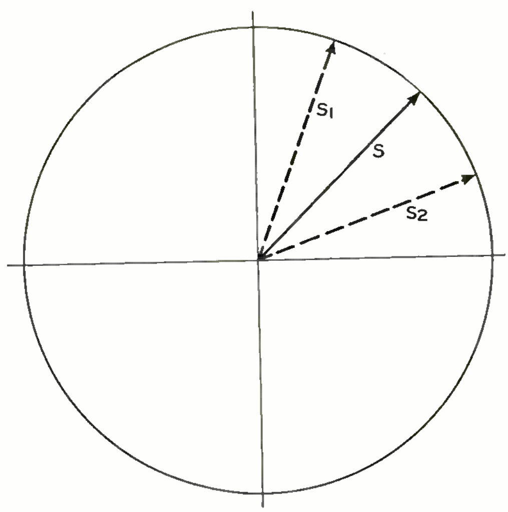


Fig. 1—An alternating current may be represented by a rotating vector, which will be at the position indicated by s *at some one point of each cycle. If this current is frequency modulated, its positions at equal time intervals, instead of remaining at* s, *will swing back and forth between two limiting positions such as shown by* s_1 *and* s_2

R may be represented graphically by adding Q to the end of S, as indicated by the dotted lines. If there is a difference in frequency of the carriers Q and S, and the frequency of S is subtracted from both, then S remains fixed in the diagram and Q rotates in the circle C at a rate corresponding to the frequency difference of Q and S. Under these conditions the resultant R, which always terminates at some point on the circle C, will vary in magnitude from (S+Q) to (S−Q) as Q

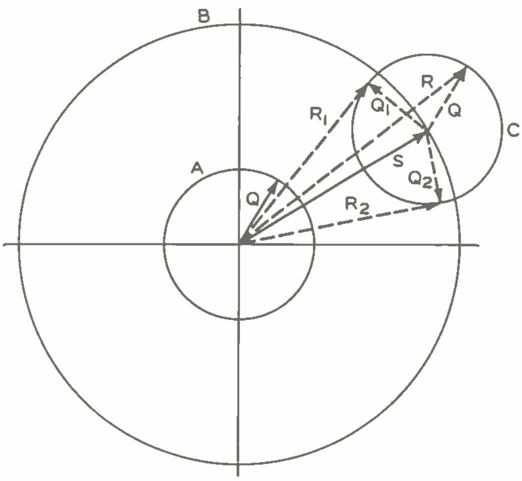


Fig. 2—The vector sum R *of two rotating vectors* Q *and* S *of different frequencies may be indicated by drawing* Q *from the end of* S *and allowing it to rotate at a speed corresponding to the difference in frequency between* S *and* Q

rotates, and will vary in phase with respect to S between the limits shown by the dotted lines marked R_1 and R_2. An FM receiver incorporates an amplitude limiting device which will wipe out the changes in magnitude of R, but the swinging back and forth of R about S causes it to be received as a frequency-modulated wave. The frequency modulation on R has a fundamental component equal to the frequency difference between the carriers S and Q, and is heard as a beat-note when it is in the audible range.

If both carriers S and Q are frequency modulated with voice signals, S will swing back and forth about its unmodulated position and, similarly, Q will swing back and forth as it rotates relative to S. The resultant R will move back and forth through a wider angle than that between R_1 and R_2, as a result of the frequency modulation of S, but its mean position will remain the same as S. When R is detected in an FM receiver, the modulation on S will be reproduced in its original form, whereas the modulation on Q will show up as a modification of the interfering beat-note.

The strength of the beat-note varies with the amplitude ratio of the desired and interfering carriers S and Q, but the amount of audible interference it produces depends also on the amount of time that the instantaneous frequency difference of the carriers lies within the limits of audibility. In the practical situation, where the carriers are modulated over a wide range of frequency, the instantaneous frequency difference is audible only a small percentage of the time, and the beat-note interference is considerably weaker than the desired signal modulation, even when the interfering carrier is nearly as large as the desired carrier.

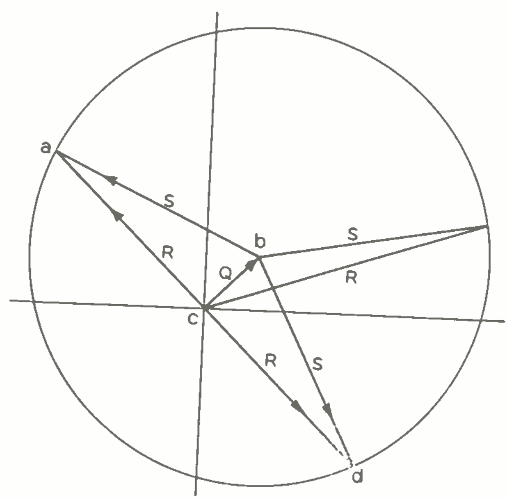


Fig. 3—The vector sum R *of two rotating vectors* Q *and* S *may also be represented by adding* S *to the end of* Q, *and in its frequency relationships this diagram is exactly equivalent to that of Figure 2*

To understand what happens when the interfering carrier Q becomes larger than the desired carrier S, it will be well to return to Figure 2 for a moment. The interaction of the two unmodulated carriers was there illustrated by adding Q to the end of S and allowing it to rotate at a speed corresponding to the frequency difference of S and Q. The resultant R could also have been obtained by

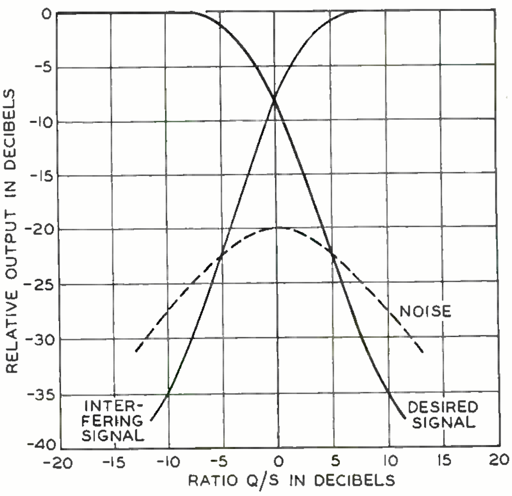


Fig. 4—Performance of a typical FM system

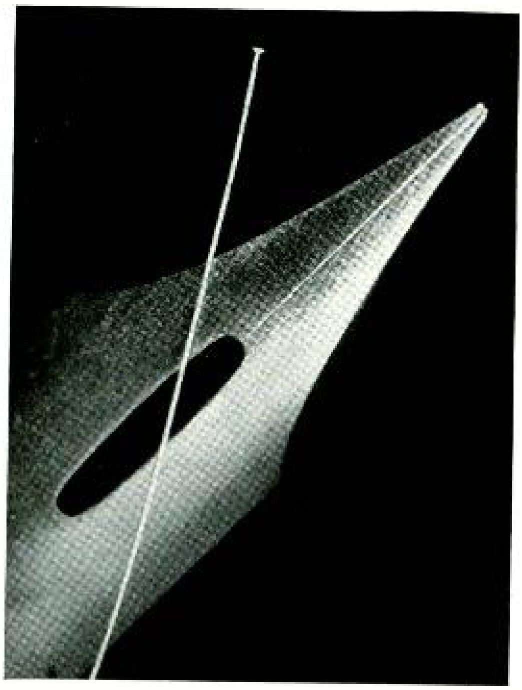
fixing Q and letting S rotate, as shown in Figure 3. This diagram appears to be entirely different from that of Figure 2, but the difference is apparent rather than real. It can readily be shown that each possible triangle of R, S and Q in Figure 3 corresponds to one of the possible triangle of Figure 2. That is, the angular relationship between R and S goes through the same cycle of variation in Figure 3 that it does in Figure 2. The greatest angular separation between R and S is represented in Figure 3 by triangles abc and dbc, exactly equivalent to triangles R_1SQ_1 and R_2SQ_2 in Figure 2.

Now suppose that while a program is being received under the conditions indicated in Figure 2, some momentary peculiarity in the transmission path causes the undesired carrier Q to become stronger than the desired carrier S. This change in relative amplitudes would make the vector diagram look like Figure 3, but with the labels Q and S interchanged. Since Figure 3 and Figure 2 are exactly equivalent, however, the new condition could be represented in the form of Figure 2 by calling the longer, stationary vector, Q and the shorter, rotating vector, S. In other words, the rôles of the vectors Q and S are interchanged. Under these conditions the modulation on Q is reproduced by the receiver, while the desired signal modulation on S becomes submerged in the beat-note interference.

In theory, the desired program drops out abruptly and the unwanted program takes over at the point where the interfering carrier just begins to exceed the desired carrier. This assumes perfect amplitude limiting, which cannot be attained practically when the two carriers are nearly equal in amplitude. Under these conditions the magnitude of R varies from a very small value to a maximum which is nearly twice S. Hence in practice there is a narrow range of Q/S values, near unity, within which both programs can be heard because of the imperfect amplitude limiting in the receiver. However, when Q exceeds S by a factor of about 2, the desired program is effectively overridden by the unwanted program.

The performance of a typical FM system is illustrated in Figure 4, where the relative levels of desired signal, interfering signal, and beat-note noise at the receiver output are plotted against the ratio of interfering carrier to desired carrier at the receiver input. As the ratio Q/S increases from about −5 db, the interfering signal output rises rapidly, and the desired signal begins to drop. When Q/S has reached +5 db, the desired signal has been reduced to a point some 20 db below the interfering signal, and is about to disappear in the noise. In other words, there is a range of only about 10 db in the ratio Q/S between the point at which the interfering program just begins to be noticeable and the point where it practically obscures the desired program.

THE AUTHOR: A. L. DURKEE received the degree of B.S. in Engineering from Harvard University in 1930 and joined the Department of Development & Research of the American Telephone and Telegraph Company in July of that year. There, and as a member of the Laboratories following the consolidation in 1934, his work has been largely on radio transmission problems associated with the development of transoceanic and other radio-telephone circuits. Recently he has been engaged in radio propagation studies associated with the development of communications systems for military applications.



Wire-Supported Crystals

By A. W. ZIEGLER
Transmission Networks Engineering

A QUARTZ plate cut from the natural crystal will vibrate at resonance in a number of distinct fundamental modes and overtones of these modes, depending on how the plate is prepared and mounted. A crystal unit is generally designed to utilize efficiently the resonance of some specific mode at some specific frequency. Three major considerations are involved: the selection of the dimensions and angles of cut for the plate; the arrangement of electrodes for applying the alternating electric field to drive the plate; and the mounting features of the plate, which must be arranged so as to detract as little as possible from its vibration. For those plates that have definite nodal lines or nodal points of minimum motion, as contrasted with such plates as the AT and BT cuts which vibrate in thickness shear modes, a mounting method has been developed that almost entirely eliminates the adverse effect of the mounting on the plate.

A quartz plate is inherently an efficient resonator; its internal damping is very small, and its ratio of inductive reactance to effective resistance, Q, is thus large. A well-mounted crystal plate in a vacuum may have a Q of several hundred thousand. Another inherent property of a quartz plate is that its frequency-temperature coefficient is determined by the dimensions and angles of cut, and for some cuts is substantially zero over a wide temperature range. Furthermore, unless the crystal plate is driven at too great an amplitude, the frequency of resonance will not change with time.

The problem of mounting the crystal plate is one of preserving the valuable characteristics of the plate, and at the same time of having a crystal unit that is economical to manufacture and capable of withstanding reasonably rough handling. The more nearly all vibration, and hence all energy loss, can be confined to the plate itself, the more nearly will the inherent properties of the plate be realized. This problem loomed large in former years when the crystal plate was held by mechanical clamping. The clamps were provided with contacts of small area placed with considerable backing pressure at or along one of the nodes of the crystal plate. As a node in the type of plates under discussion is a point or line of zero area, while any practical contact point has a finite area,

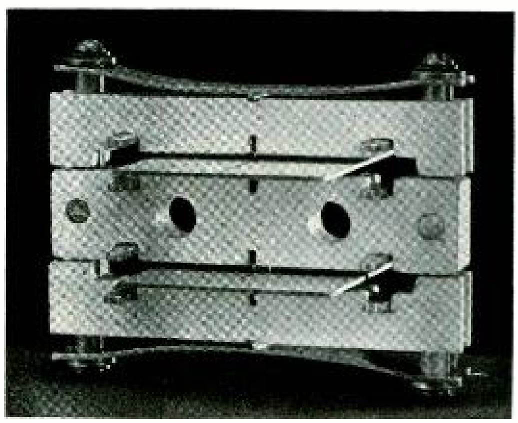


Fig. 1—Typical four-contact clamp-type mounting used for filter crystals

these contacts may adversely affect the crystal vibrations. Moreover, the size and position of the contacts may change with temperature and thus produce changes in performance with temperature.

The simplest of these mechanical clamps comprised two opposing circular flat-faced contacts in accurate axial alignment within a highly insulating steatite frame. These clamps were used generally with the smaller high-frequency crystal plates whose driving electrodes were continuous over each of the two major surfaces. When crystal plates are used in balanced filters, it is the practice to make each physical plate function as two by dividing the driving electrode into two equal longitudinal areas. In this case, four contacts with the driving electrodes were required, necessitating the development of a considerably more complicated mounting. The contacts of each side pair were placed close together to minimize damping, and required high contact pressures to secure adequate mechanical stability. Sometimes the plate would shift position and cause a frequency change, or the contacts would wear through the electrode and open the circuit. Despite these difficulties, satisfactory crystal clamps of both the two- and the four-contact types have been manufactured in quantity. A typical four-contact clamp for filter use is shown in Figure 1, which is an arrangement whereby two crystal plates of the divided electrode type are accommodated. The plate electrodes are aluminum, and offer high resistance to wear. Irrespective of such improvements as were realized from time to time, it appeared that clamps of this general type were fundamentally limited in their ability to utilize adequately the valuable properties and characteristics of the vibrating quartz plate.

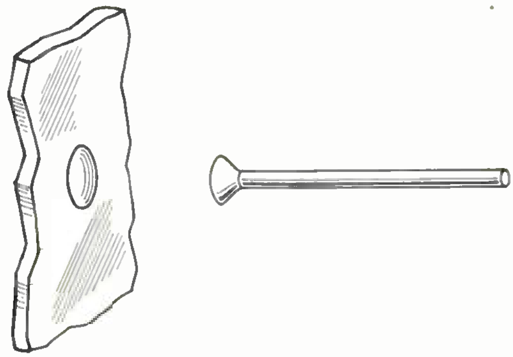


Fig. 2—Headed bronze wire is soldered to a silver spot on the face of the crystal

An ideal supporting system would hold the crystal in place with constant resonant frequency maintained even when it was subjected to severe shock, would exert no pressure on the crystal to cause damping, and would not shift on the crystal with temperature so as to cause a variation in the temperature-frequency characteristic. From a practical consideration, for large-scale use it would also be simple to manufacture. With these objectives in mind, a development was undertaken which has culminated in what is known as the "wire-supported crystal," which, because of several inherent advantages, has largely replaced the mechanical type of clamp.

The new crystal-support system employs fine wires to fix the position of the crystal

Fig. 3—Soldering machine designed for making wire-supported crystals

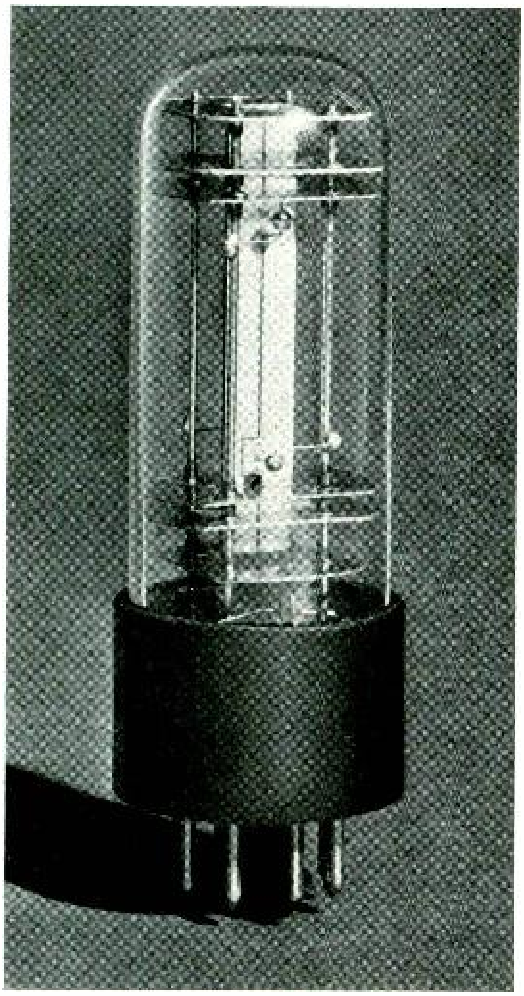


Fig. 4—A filter crystal in its sealed tube

plate within the container and to make the necessary electrical contacts with the driving electrodes. A phosphor bronze wire, the diameter depending on the mass of the plate to be supported, is headed as shown at the right of Figure 2 to provide a flat surface for attaching to the crystal. A small spot of silver paste, slightly larger than the face of the cone on the wire, is placed on the crystal at the position for the wire attachment and "fired" to the crystal to secure strong adhesion. After the firing, the surface of the crystal is plated—usually by evaporated silver—to form the driving electrode. The end of the wire is then "tinned" and pressed against the silver spot on the crystal at soldering temperature. Sufficient pressure is applied so that all but a thin film of solder is forced out. A strong sweated solder joint is thus obtained. The two wires, one for each side, or the four wires if a divided electrode crystal is used, are soldered at the same time in a machine specially designed for the purpose and shown in Figure 3. This machine accurately aligns the wires on the two sides of the crystal and presses them against the surface while blasts of hot air from small retractable nozzles apply the required heat for the proper period. These mount wires are then soldered to relatively heavy support wires forming a "cage assembly" that is later sealed in a glass or metal container to give a finished crystal unit as shown on the cover of this issue and in Figure 4.

In this design, the crystal floats on these fine wires and is essentially free from damping action. As there are effectively no stresses within the crystal between contacts, the supporting system does not add appreciably to internal loss, and the inherently high Q of the crystal is preserved. To prevent the support wires from being strained beyond their elastic limit under the influence of external vibration or shock, slotted mica "spacers" are placed around

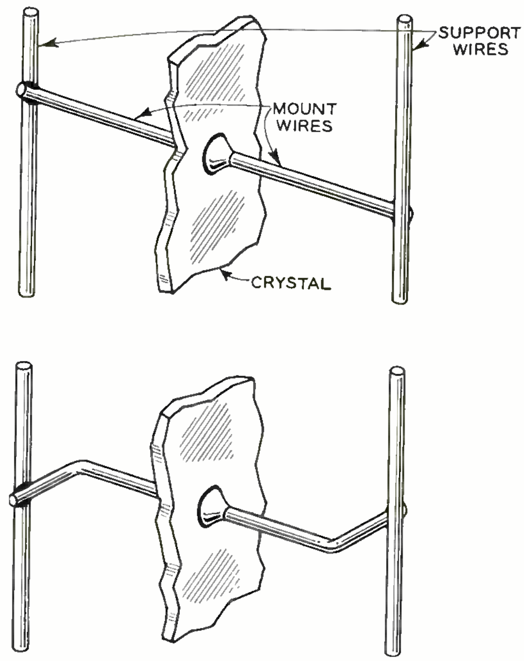


Fig. 5—Instead of fastening support wires at their ends, as above, they are bent at least once, as below, before being attached

the crystal at each end, and plain mica spacers are placed just above and below the top and bottom edges of the crystal. Under shock conditions, the crystal strikes the relatively soft mica stops without damage to itself or to the mount wires. After the crystal has been deflected to the stop, the resilient mount wires return it to its normal position.

Since the mount wires should not exert more force on the crystal than is necessary to suspend it freely, it would be undesirable to use wires running straight back to the relatively heavy support wires as shown in the upper part of Figure 5. Under certain static conditions, considerable tension might develop between wire and crystal and produce internal stresses within the crystal similar to the stresses caused by mechanical clamps. Furthermore, unless some member of the supporting system yielded under shock conditions, rupturing forces between the crystal and wire attachment would develop. The mount wires are therefore bent—one typical arrangement being shown in the lower part of Figure 5. For some applications where more uniform compliance in all directions is desired, two bends are used instead of one. These formed wires permit the crystal to move in any direction with no restriction except slight bending moments.

In the development of wire-supported crystals, it was found that because of the small constraints offered by the wire supports, the distance between the position of wire attachment and the nodal point was not as critical as with the mechanical clamp. However, when the wire is attached to a position appreciably removed from a node, a mechanical coupling is created between the vibrating plate and the supporting wire system. There are occasions, therefore, depending on the relation between the frequency of the plate and the effective length of the mount wire, when some of the energy of the vibrating crystal is transmitted to the support system. When this happens, the crystal becomes damped and the Q lower. Even when the mount wires are attached to the crystal at a node, the finite attachment area extending into the region of quartz movement may cause a slight damping. To prevent transmission of this vibration to the support wires, a ball of solder of proper mass is placed on the mount wire at a point that effectively clamps the wire and allows the end attached to the crystal to vibrate freely. The proper location for this mass is at distances approximately that of odd multiples of the one-quarter wave length of the wire for flexure waves in the wire. In practice, the location used for crystals in the frequency range of 12 to 250 kilocycles is slightly beyond one-quarter wave length, and for crystals in the range of 250 to 1,000 kilocycles, it is slightly beyond the three-quarter wave length. The solder weights now used for wire-supported crystals are visible in Figure 4. For higher frequencies, small copper discs backed with solder are sometimes used because they can be located more precisely than balls of solder.

Crystal units constructed on these princi-

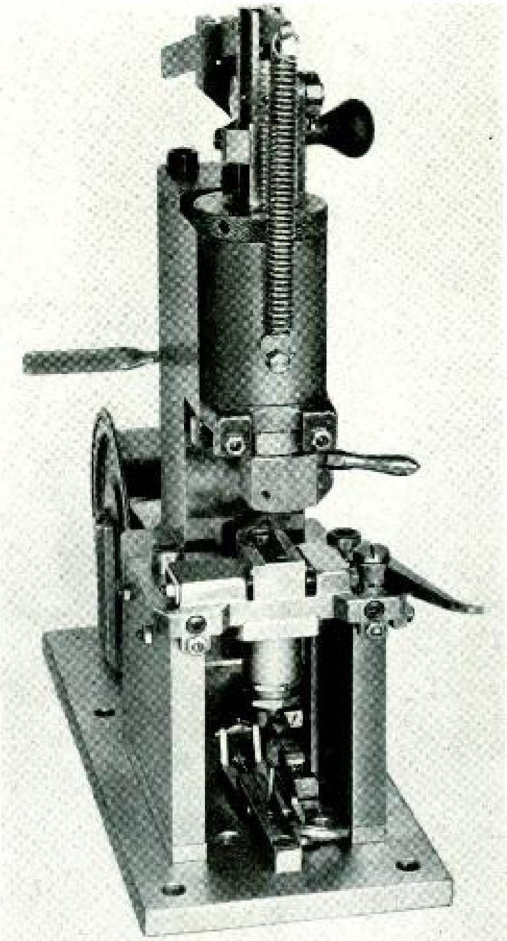


Fig. 6—Heading machine developed to form the coned heads on fine support wires

ples have been made in large quantities during the last few years. With such wire-mounted crystals, it is easier to make manufacturing adjustments with precision, since once the lead wires are attached to the electrodes, they remain there during subsequent operations. The fabrication of these crystal units, however, called for well-developed tools and fixtures. The wires supporting the crystal plate in Figure 4 are only .0063 inch in diameter, but they are large compared with the .0035-inch diameter wires used with much smaller crystals. How small this finer wire is becomes evident from the photograph at the head of this article, which shows one of these wires lying across a fine pointed pen. To form a satisfactory head on such fine wires would have seemed impossible at one time. The wire is tempered phosphor bronze and must be cold headed. If the heads were formed by heating, the temper would be lost.

At one stage of the development, a straight unheaded wire was terminated in a cone of solder attached to the crystal, and a number of variations of this scheme were also tried. Because of the comparative softness of the solder, however, the wire under small but continuous vibration with all but the relatively light crystals would gradually cup the outer end of the cone of solder and would eventually work loose. Moreover, the comparatively large mass of solder in contact with the crystal adversely affected its temperature-frequency characteristics. As a result, cold heading seemed the most desirable method, and a special machine, shown in Figure 6, was developed to do the work. It is a precision tool, built by the Western Electric Company at Hawthorne, and is provided with four complete sets of dies for cold heading wires, .0035, .005, .0063 and .008 inch in diameter. With this heading tool, with the soldering fixture already referred to, and with mechanical provisions for limiting the amount of solder to avoid crystal damping, the process results in crystals far more rugged and stable than have been possible with other methods. Because of the stability of crystals so mounted, they have been used extensively for frequency standards, and for these it is commonplace to have frequencies constant to one part in a hundred million per day.

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