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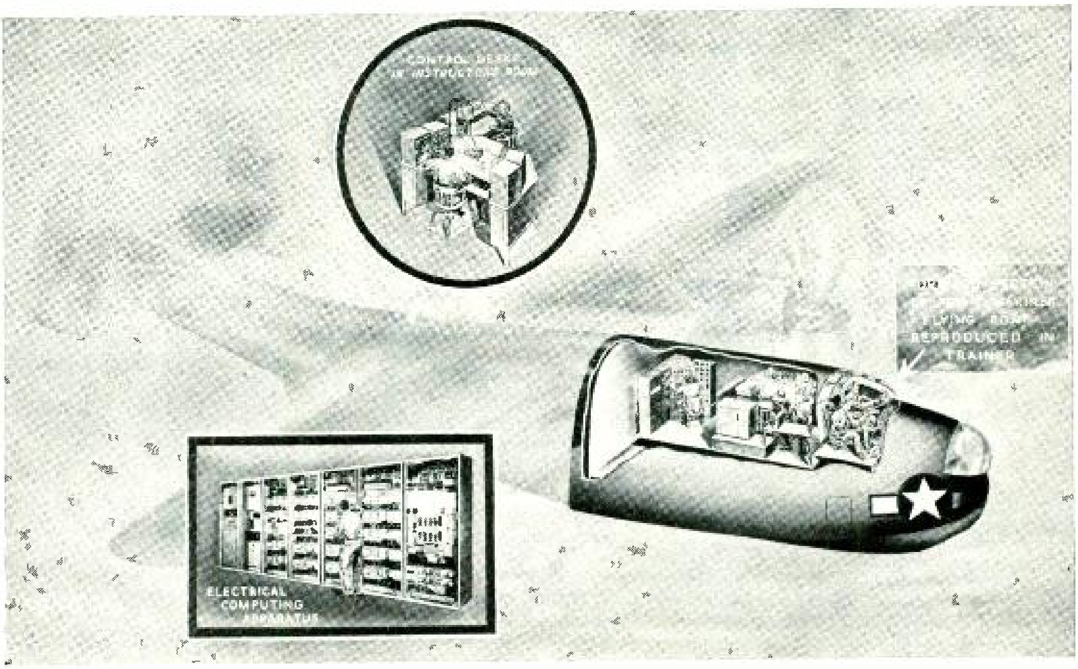


Operational Flight Trainer Demonstrated

(A U. S. Navy Press Release)

PATUXENT RIVER, Md., January 14—How an entire Navy bomber crew rehearses—on the ground—to learn to work together as a highly specialized combat team in the air was revealed in detail today. Press and radio representatives were given an opportunity to observe and operate one of the Navy's largest training devices, called the operational flight trainer, which is now in use in Naval Air Transport's flight program for training crews for flights over oceans as well as continents.

Because it teaches flight crew coördination on the ground, the device is in many ways even more complicated than the big, twin-motored Mariner flying boat it simulates. It has all the flight controls and instruments that are in the real plane. In addition, it has intricate electrical computing mechanisms which enable an instructor to tell whether pilot, co-pilot, navigator, radioman and flight engineer are doing what they should under every circumstance in flight.

The Navy's operational flight trainer even resembles the real Mariner in appearance, from the nose to a point just abaft the flight deck. Each visitor, just as though he or she was a Navy aircrewman, was permitted to go through the same actions and encounter the same problems as would be the case in the actual plane during take-off, flight and landing. Occupying stations of pilot, navigator, radioman and engineer, the visitors were given problems requiring close

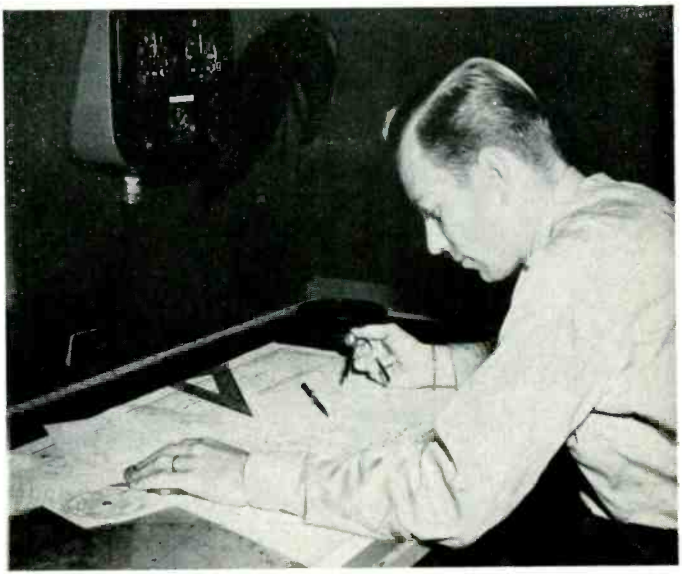
Pilot and co-pilot at controls of crew trainer

coördination of pilot and other crew members. The instructor introduced emergency conditions such as failure of one or both engines, icing, rough air, shifting of the center of gravity, and "fouled-up" fuel system. To enhance the realistic effect, the characteristic "feel" of controls, engine noise and hull vibration were experienced. Each man at his station was able to communicate with the others by means of a telephone system. Controls and switches interconnected in an electronic measuring and calculating system translated the "plane's" reactions in instrument readings and warning signals.

This elaborate trainer was developed by Bell Telephone Laboratories at the instance of Captain Luis de Florez, U.S.N.R., of Pomfret, Connecticut, head of the Bureau of Aeronautics' Special Devices Division, as a step in taking many unnecessary risks out of Navy flying. In making its request for this trainer the Navy recognized when a flight crew takes its plane on a mission, the crew is responsible for a half-million dollars' worth of equipment and the lives of ten or more men. All aboard must be consistently careful, must know each other's abilities and must be able to meet a great variety of emergencies with instant action. It has been customary to assemble men, each well trained in his own duties, and give them training in an actual ship on the ground and in the air. Flying conditions must be taken as they come; good weather is not always to be had on the day it is wanted, and some emergencies involve so much real risk to plane and crew that an instructor would not deliberately create them. Actual flight uses gasoline, wears out equipment, ties up a large investment, and is limited by weather conditions.

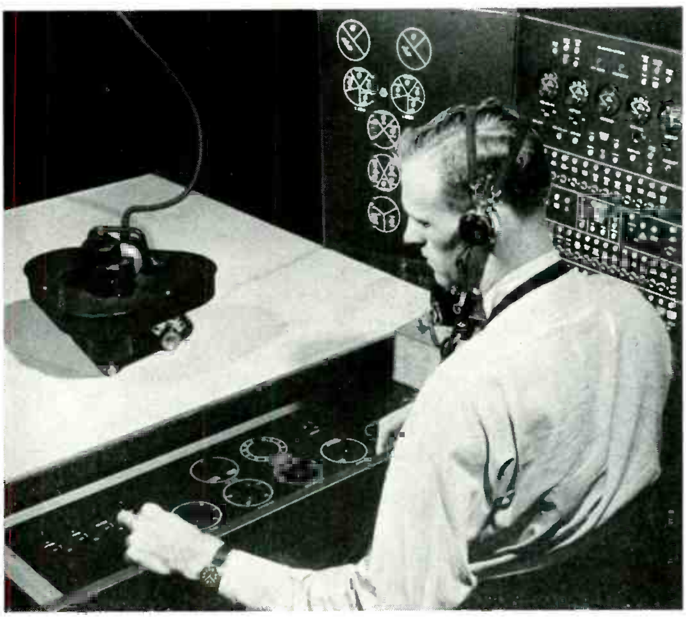
To accomplish the objectives of training Navy crews quickly and well, it was deemed necessary to portray faithfully the plane's performance and that electrical means was probably the best approach to the problem. Various types of trainers have contributed

The radio apparatus is arranged to operate in its normal manner in one way or another in aviation training, especially for single seat planes, but none was sufficiently comprehensive to accomplish the purpose the Navy desired to achieve.



Navigator at work

At Patuxent River, base of Naval Air Transport Service, the trainer installation is housed in a single story air-conditioned building situated alongside one of NATS seaplane hangars. Entering the combined office and classroom, one finds the "ship" in a room at the right, while at the left is the instructor's room with his control desk, and beyond that, the apparatus room housing the computing device with its cabinets full of relays, motors, and wiring. The "ship" is a mock-up of part of the hull of a PBM-3. Steps lead through narrow passageways to the upper deck, where one finds, abaft, the flight engineer's panels with their instruments, switches and knobs primarily for engine control. On the port side is the chart table and navigator's seat and on the starboard are the radio sets with a desk and chair for the radioman. In the cockpit are the positions for pilot and co-pilot, with duplicate flying controls and instruments, and a bank of indicators and switches in the center.



Flight Instructor's desk of crew trainer. By means of switches and dials before him, the instructor can create various difficulties, such as rough air, icing, engine failure. The device in front of him, called a "crab," traces the course that is being flown by the plane. This desk is located outside the plane, but is adjacent to it

To enhance the realism of the flight, circuits operating through loudspeakers provide engine noise and other sounds that would be heard, and still other circuits provide the vibrations that will be felt. Changing the speed of the engine produces the chain of correlated instrument indications that would actually accompany such a change. Starting and stopping the engines, taking off, and landing operations are tied into the intricate system, and provide the proper reactions and the indications of the instruments.

For the navigator, there is a chart table with an air-speed indicator, a compass and a clock above it; and at the side a drift indicator through which he sees a vertical view of the ground passing at an angle and speed proportional to the amount of cross-wind and the plane's speed.

Radio instructor's desk of the crew trainer. This represents a control tower, or a squadron leader, or other planes in the flight

A crew in this Navy trainer can simulate starting the plane, making a flight, returning and landing and scarcely be aware that the ship is all the time safely resting on the ground. To take full advantage of such equipment, however, an instructor should be able to follow all the actions taken by the crew, to give instructions when necessary, to know the actual course that would be flown as a result of the actions of the crew, and also to be able to adjust conditions so as to find out how the crew responds to emergencies or to changed conditions of flight. All this is made possible by the instructor's desk which is outside the plane, but adjacent to it.

On the panels at the two sides of this desk are instruments duplicating those in the plane, both at the pilot's and engineer's positions. By watching these instruments, the instructor can see just what is going on in the plane at all times.

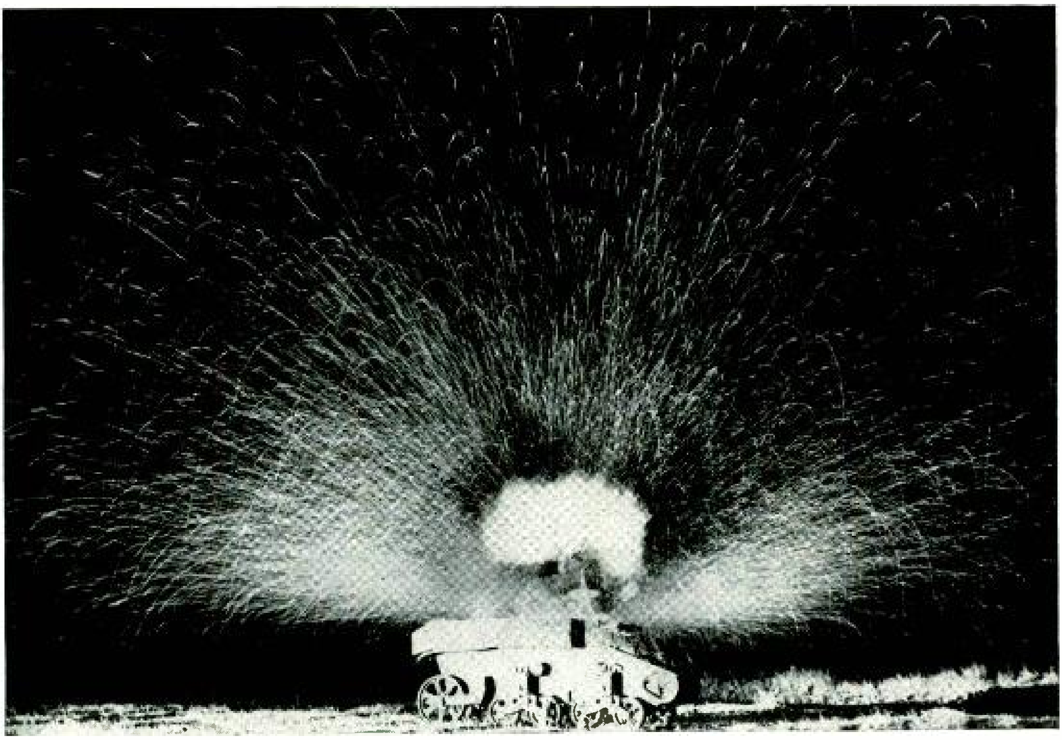
He can bring about changed conditions such as velocity and direction of wind, icing of the wings, rough air, changes in weight and center of gravity, and by which he can disable either or both of the engines. His controls also connect the instructor into the inner-communication system of the plane, so that he can give instructions to the crew as needed. On top of the desk is placed a chart that is applicable to the flight to be made. Resting on the chart is one of the flight recorders used with the Link trainer, popularly known as the "crab."

An instructor seated at this desk can watch every move made by the crew in a training flight. He can call attention to errors of operation when it seems desirable and can initiate flight problems that will require prompt and correct thinking on the part of the crew. He can check the navigation and overall handling of the ship.

A radio instructor's desk is provided, in addition, to give practice in the operation of the radio equipment of the plane. All radio transmitters and receivers are arranged to operate in their normal manner.

The first of these electrical crew trainers was completed in Bell Telephone Laboratories in 1943 and was installed by the Navy at its training center at Banana River, Florida, where it is now in use daily. Subsequent trainers were built by Western Electric Company, manufacturing associate of the Bell System.

The operational flight trainer at Patuxent River, Maryland, is now used by Naval Air Transport Service for its oceanic flight crews. Trainers for other types of planes are now under development and construction.



Rocket Researcher

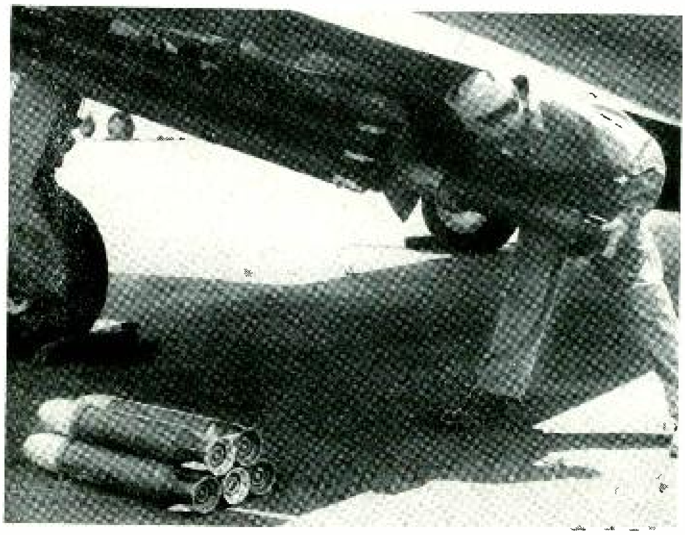
IN 1917 Dr. R. H. Goddard, professor of physics at Clark University, was working on the problem of shooting meteorological instruments into the upper atmosphere by means of rockets. A young graduate student, Clarence N. Hickman, joined him in 1918 and immediately showed one of those flashes of inventive genius for which he afterward became noted. Dr. Goddard's rocket was to fire one powder charge after another; Dr. Hickman's idea was to pop the charges into the muzzle of the explosion chamber instead of the breech by a method that would remind us today of the pin-ball machine and the way it brings up and fires one ball after another. The Government was interested in the military possibilities of long-range rockets and was supplying funds. While experimenting with the multiple charge rocket, a defective charge exploded in Dr. Hickman's hands; swathed in bandages, he was back on the job in three days.

In view of that war's immediate needs, it was decided to abandon the promising multiple-charge idea and concentrate on a single-charge rocket of shorter range. Progress was rapid; early in November, 1918, successful demonstrations with ranges of several hundred yards were made at Aberdeen Proving Ground. Then came the Armistice and the investigation was virtually discontinued.

With the outbreak of the European war, there was a tremendous quickening of thought on military devices. Dr. Hickman, by that time a member of the Laboratories, dusted off his files and wrote a memorandum outlining his earlier experience to Dr. F. B. Jewett, then Chairman of our board of Directors. He suggested that rockets had a number of military applications. Through contacts in Washington, Dr. Jewett brought Dr. Hickman to the attention of the Na-

The photograph above shows what happens to a tank when a bazooka shell hits it. U. S. Army Signal Corps Photo tional Defense Research Committee and by the end of July, 1940, he had been sworn in as chief of a section of the Committee's Division of Armor and Ordnance. Arrangements were made by the Laboratories to make his services available to the OSRD for the duration.

Soon after starting work, Dr. Hickman met Col. L. A. Skinner who also had a personal interest in rockets. In fact, while an instructor in the Ordnance School at Aberdeen, Col. Skinner had seen the Goddard-Hickman reports and begun experimenting with rockets on his own account, building models in his own shop and testing them himself. At the request of Dr. Hickman, Col. Skinner was appointed liaison officer from Ordnance to follow the NDRC developments. Their initial problem was a rocket to be mounted on an airplane. The art was entirely new and development was required at every point. A means had to be found to secure the powder charge so that the blast would not blow it out; fins must be designed that would stabilize the flight and yet pass through the launching tube; a nozzle must be provided to prevent excessive turbulence of the gases as they reach the air. Numerous firing tests were made and recorded by the ribbon-frame camera described on page 40 of this issue of the Record. In due course the development passed through the stages of field trial and adoption to that of widespread use by the Armed Forces.



U. S. Air Forces Photo

Loading 4.5-inch rockets in cluster tubes on the wing of a P-47 airplane. Note the light supports for the launchers of 40-lb. projectiles

To understand why the rocket is so useful a weapon for the airplane, one must remember that a projectile weighing several pounds requires a considerable push to accelerate it to several hundred feet per second. When this push is exerted by a cannon, its reaction is so severe that no airplane wing will take it. A rocket, however, reacts against the mass of its own gases, and there is no force on the airplane. The launching tube is not subject to high pressure, but merely serves as a guide, so it can be quite light and inexpensive.

U. S. Army Photo

With this expendable launcher, a 4.5-inch airplane rocket can be handled by Infantry. The shell will penetrate several feet of logs and earth and explode inside a bunker. R. F. Mallina of the Laboratories contributed to the early stages of this development

To make this 4.5-inch airplane rocket available for ground troops, Ordnance has developed an artillery launcher, known as the M12, consisting of a plastic tube. The tube has three legs attached to it, and may be set up for firing from a foxhole, from against a tree, or in the open. The launchers may be wired into batteries to hurl salvos of 4.5-inch projectiles into enemy positions. The M12 is easily carried by one man. Several may be loaded into a jeep and rushed into action.

At the same time, Ordnance had the problem of projecting a grenade which weighed about three pounds and which was amazingly successful against armor. When shot from a gun, the recoil was too heavy, so the development of a rocket was undertaken by the NDRC-Army Ordnance group with Lieut. E. G. Uhl as project engineer. Outcome of this work was the bazooka, a rocket launcher to be loaded with a 2.36-inch projectile by one soldier and then fired by another soldier.

The bazooka is now well known for its effectiveness against tanks. Bazooka teams have knocked out even the giant German tiger tanks. In one case a GI bazooka man blew the turret off a Nazi tank from 75 yards. In a single day of fighting, two-thirds of a German Panzer force was knocked out or damaged by bazooka teams and aircraft rockets. The bazooka rockets themselves do not penetrate armor, but punch a hole through thick steel plate by a terrific concentrated and directed blast effect that throws hot fragments of steel around inside the tank. In some cases, rockets have blasted as much as six inches of armor plate.

Dr. Hickman's researches into rockets continue, and when security permits the story to be told, it will show that he and his associates have made a major contribution to ordnance.

U. S. Army Photo

The bazooka developed in Dr. Hickman's laboratory as a joint project of Army Ordnance and NDRC

The Ribbon-Frame Camera

By FRANK RECK
Special Apparatus Development

PERHAPS the most spectacular weapon of this war has been the rocket. First appearing in connection with the "bazooka," a light-weight rocket launcher held by one soldier, rockets are now being applied to several types of our fast fighter planes. In one action, Japan's dwindling barge fleet at Rabaul suffered a crippling blow when American P-39 Aircobras swept down from the clouds and sank forty enemy barges with their rockets. They blasted the Jap barges into splintered wreckage, set off huge explosions, and started numerous fires among ground installations. This was not the first use of rockets in aircraft, but it was one of the most spectacular.

This rocket, known as the artillery type, can also be launched from mounts attached to landing craft, or set up on the ground. Each rocket weighs less than fifty pounds, but has the destructive effect of a 105-mm howitzer shell. The great advantage of using rockets is that they require no heavy structure to absorb the reaction of their launch-

TABLE I—ANGULAR POSITIONS IN DEGREES OF THE EDGES OF THE SLOTS OF THE TWO DRUMS WHEN THEY ARE IN THE POSITIONS SHOWN IN FIGURE 1

Outer Drum	*Inner Drum*
A=7	K-11
B=47	L=61
C=79	M=101
D=119	N=151
E=151	O=191
F=191	P=241
G=223	Q=281
H=263	R=331
I=295	
J=335	

ing. The product of mass and backward acceleration of the burning gas just equals that of the mass and forward acceleration of the projectile, and ideally, no force is applied to the housing from which the projectile is launched. With a gun, on the other hand, the burning gases behind the shell build up a pressure to launch it, but the reacting force is taken by the gun mount, which must thus be very strong and heavy. This weight is an important consideration with airplanes and thus limits the size of gun that can be carried. In addition, the reaction on the gun mount tends to slow down the plane if the shell is fired forward, while with a rocket there is no reacting force on the plane

Early in the war, the National Defense Research Committee, knowing Dr. C. N. Hickman's long-time interest in rocket propulsion, requested the Laboratories to make his services available. Not only was this done but, in addition, the Laboratories has been called upon to attack a number of related problems for which it had suitable background and facilities. As a result, several of our engineers have made substantial contributions to the art. Disclosure must await the end of the war. One laboratory tool, however, the "ribbon-frame camera," may be described; and it should be of interest to engineers not only for its ingenuity but because of its applicability to problems in other fields.

To gain knowledge of the behavior of rockets during the early part of their flight, some form of high-speed camera is essential. Since the path of the rocket is practically a straight line over moderate distances, the frame of the picture should be ribbon-like — hence the name. One form of camera had been devised by Dr. I. S. Bowen of California Tech., but duplicates were not available, and it was accordingly decided to re-design it in the interest of simplicity and lightness. Dr. Hickman made up some sketches and turned to the present writer for the detailed design and construction of the first model. Over a score of the cameras have been made, and

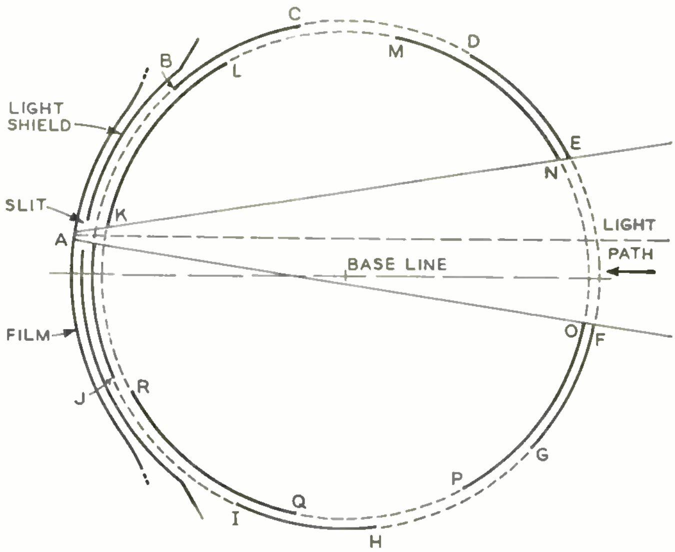


Fig. 1—Cross-section of the two drums forming the shutters

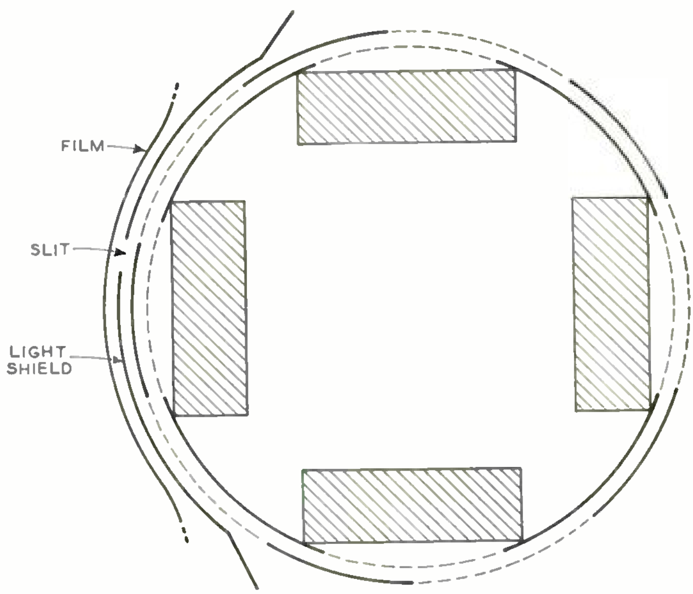


Fig. 2—Optically flat glass plates attached to the inner drum rotate the light beam downward at the speed of the film

are rendering valuable service in the war.

The camera uses a standard No. 122 film, which is 3¼ in. wide and 35 in. long. The film is carried past a .15-in. slit, and each frame is thus .15 in. high and 3¼ in. wide. Over 200 frames may be taken on a single film. The exposure time is adjustable from .0001 to .0006 second. A dial on the outside of the camera indicates the amount of unused film, and where the number of frames taken per set is small, several sets may be taken on the same film.

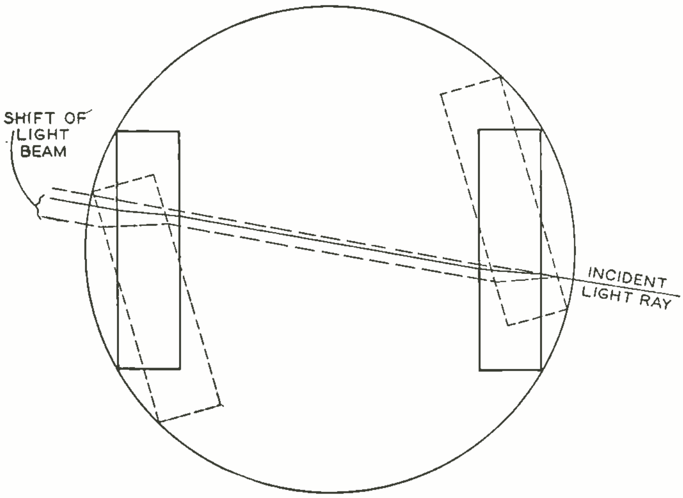


Fig. 3—The displacement of the light beam due to defraction through the glass plates is greater at the end of exposure (indicated by dashed lines) than at the beginning

One of the novel features is the shutter arrangement. It consists of two concentric drums 2¾ in. in diameter and 4½ in. long which are rotated in the same direction but at slightly different speeds by a single constant-speed motor. In each drum there are wide slots running nearly from end to end: four in the inner and five in the outer. All slots in both drums are 40 degrees wide, but the solid sectors between the slots are 50 degrees wide in the inner drum, and 32 degrees wide in the outer. The inner drum, coupled directly to the motor, rotates at 30 revolutions per second, while the outer drum is driven at 24 revolutions per second made possible by means of a gear train from the inner drum.

These two drums are shown in cross-section in Figure 1 as they would be at some particular instant. For purposes of identification, the edges of all slots are lettered—A to J for the outer drum and K to R for the inner. In the position shown, there is a 40-degree gap through both drums at the right, and a 4-degree gap at the left between edge A of the outer drum and edge K of the inner. The angular positions of the edges of the slots of the two drums, from a horizontal base line through the center, are given in Table I on page 40.

Because of the difference in the number and spacing of the slots, and of the difference in speed of the drums, these same two gaps, wide at the right and narrow at the left, will appear after each quarter revolution of the inner drum. After a 90-degree revolution of the inner drum, edge M will be where edge K was before, having moved from 101 degrees to 11 degrees. During the same time, edge C of the outer drum, moving four-fifths

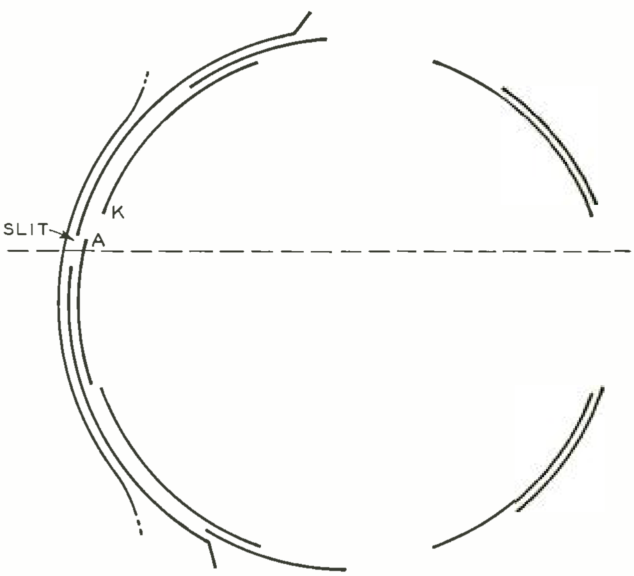


Fig. 4—Position of the shutters of the ribbon-frame camera at the beginning of exposure

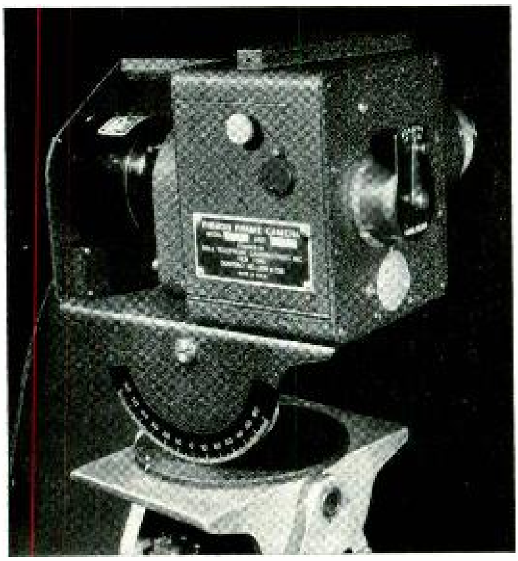


Fig. 5—A timing arm on one end of the camera permits setting the exposure time over the range from .0001 to .0006 second

as fast, would travel 72 degrees, and be where edge A had been —moving from 79 degrees to 7 degrees. At the end of another 90-degree rotation of the inner drum, this same situation would again be reproduced with O being where M had been and E where C had previously been.

Four times for each revolution of the inner drum, therefore, there is a wide opening at the right and a narrow opening at the left; for the rest of the time the slit is completely covered by the solid sectors of the inner or outer drums. By mounting a light source and a suitable optical system at the right, and arranging to carry the film past the slit at the proper speed, exposures may be made at the rate of 120 per second—four for each revolution of the inner drum.

Just outside of the outer drum is a light shield with a .15-in. slit opposite the AK gap at the left of Figure 1. The film rides over the surface of the light shield, from a supply roll above the shutter to a take-up roll below them. It is driven through gears from the shutter-drive motor, and runs about 18 in. per second—varying slightly from this value as the supply reel empties and the take-up roll fills up.

Because of its continuous motion, the film will move from two to ten-thousandths of an inch during the short exposure time. To prevent the blurring of the image that such motion might cause, four glass plates, ground optically flat, are attached to the inner drum just inside the four slots as indicated in Figure 2. A light ray passing through these plates is refracted, and leaves the glass along a line parallel to, but offset

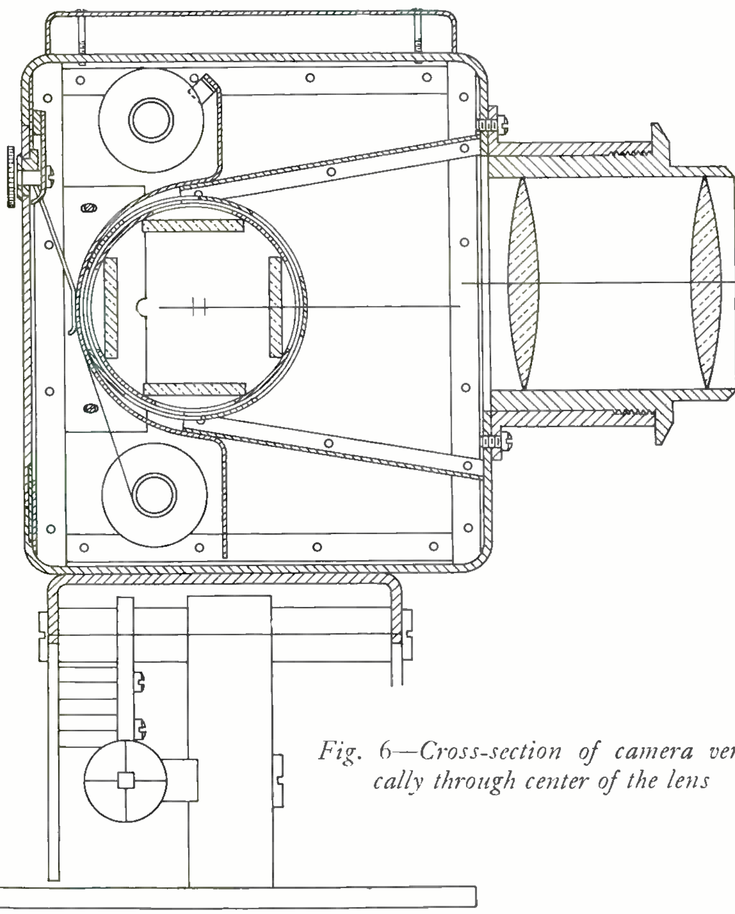


Fig. 6—Cross-section of camera vertically through center of the lens

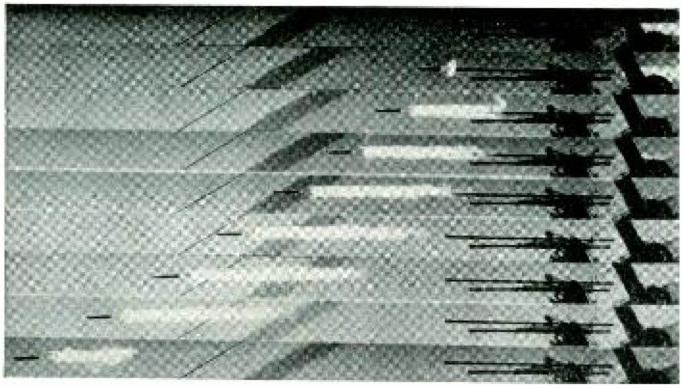


Fig. 7—Flight of a 4½-in. rocket as photographed by the ribbon-frame camera

from, the original track of the ray by an amount depending on the thickness of the glass and the angle at which the incident light ray strikes it. The angle of incidence is greater at the end of the exposure than at the beginning, and thus the ray is offset more at the end than at the beginning. As a result, the rays striking the film move downward during the exposure time. By properly choosing the thickness of the glass, this downward motion can be made just equal to the motion of the film. This is indicated in Figure 3, where dashed lines show the position of plates and light ray at the end of the exposure, and solid lines the positions at the beginning.

The position of the drums at the beginning of an exposure is shown in Figure 4. Edge A of the outer drum is just on the point of opening a light path to the upper edge of the slit. The exposure time for the film at the upper part of the slit will thus last until the edge K of the inner drum has moved down to cut off the light. The exposure time for this part of the film is thus the period required for edge K to move from the position shown in Figure 4 to the upper edge of the light slit. In other words, it is the time required for the inner drum to travel the distance of the AK gap. Since the inner drum moves at the rate of 30 rps, it is moving 30 × 360 = 10,800 degrees per second. The distance AK divided by 10,800 degrees, therefore, gives the exposure time, which will be .0001 second when AK is 1.08 degrees and .0006 second when AK is 6.48 degrees. The exposure time may thus be varied by shifting the relative positions of the inner and outer drums. As the drums rotate, lower sections of the film will be consecutively exposed, but for any one section the exposure time is that required for the inner drum to move the distance AK. Because of the relative motion of the two drums, this gap will be somewhat less at the lower end of the slit than at the upper. The closing of the gap is so small, however, that it does not appreciably affect the exposure time involved.

As already mentioned, the outer drum is driven from the inner drum through a gear train. One of the elements in this chain is a planetary gear rotating around a stationary gear, and if the stationary gear is rotated, the relative positions of the inner and outer drums will be displaced proportionately. An arm fastened to the stationary gear is mounted on the outside of the camera as shown at the right of Figure 5. This arm is brought to a point at its upper end, and its

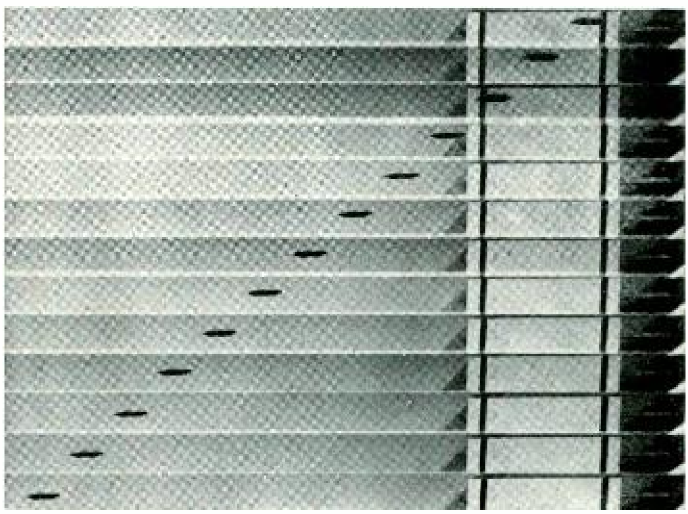


Fig. 8—Photographs of the flight of a 4.2-in. shell

position is indicated by a scale marked in exposure time. As the arm is moved to various exposure times, the stationary gear is rotated so as to make the gap AK the proper width to give the desired exposure.

The relative positions of the drums, lens, light shield, and film are shown in Figure 6. All light is excluded by the shield from the rear compartment of the camera except that passing through the slit. The back of the camera is hinged along the bottom edge and may be opened for inserting or removing the film. On the top of the camera is a fan-shaped view finder shown in both Figure 5 and in the photograph at the head of this article. The wide end on the lens side of the camera has a narrow slit that marks out the field of view, while at the narrow end of the rear is a small peep-hole.

In preparing to take a set of photographs, the camera is set up at such a distance from the path of the projectile that the desired section of the path will be included. When the path is not horizontal, the camera is tilted to the proper angle by a thumb screw just behind the graduated scale evident in Figure 5. When the angle of fire is known, this angle may be set on the dial. As the rocket or shell is fired, the clutch button just below the motor is pressed as shown in the headpiece photograph. This connects the film roll to the drive, and by starting the film, starts a set of exposures. Exposures will continue to be made as long as the clutch is held in. Typical results obtained with the camera are shown in Figures 7 and 8. The former shows a 4½-in. rocket and the latter a 4.2-in. shell. From such photographs, the ignition time, burning time, velocity, acceleration, and yawing of rockets may be determined. Results from the camera have been very gratifying, and there has been a steady demand for these instruments.

THE AUTHOR: FRANK RECK graduated from The Frankfort on Main Technical Institute in 1918. He joined the Laboratories in 1928, and worked first as an instrument maker in the Model Shop. In 1934 he was transferred to the Research Department, where he engaged in the development of magnetic tape recording machines. In 1937 he transferred to the Apparatus Development Department with R. F. Mallina's group, and worked on new designs of automatic switching equipment and push-button telephones. During the war he has been engaged in designing anti-aircraft computers and optical apparatus for the Armed Forces.

"GI JOE WITH A WIRE IN EACH HAND"

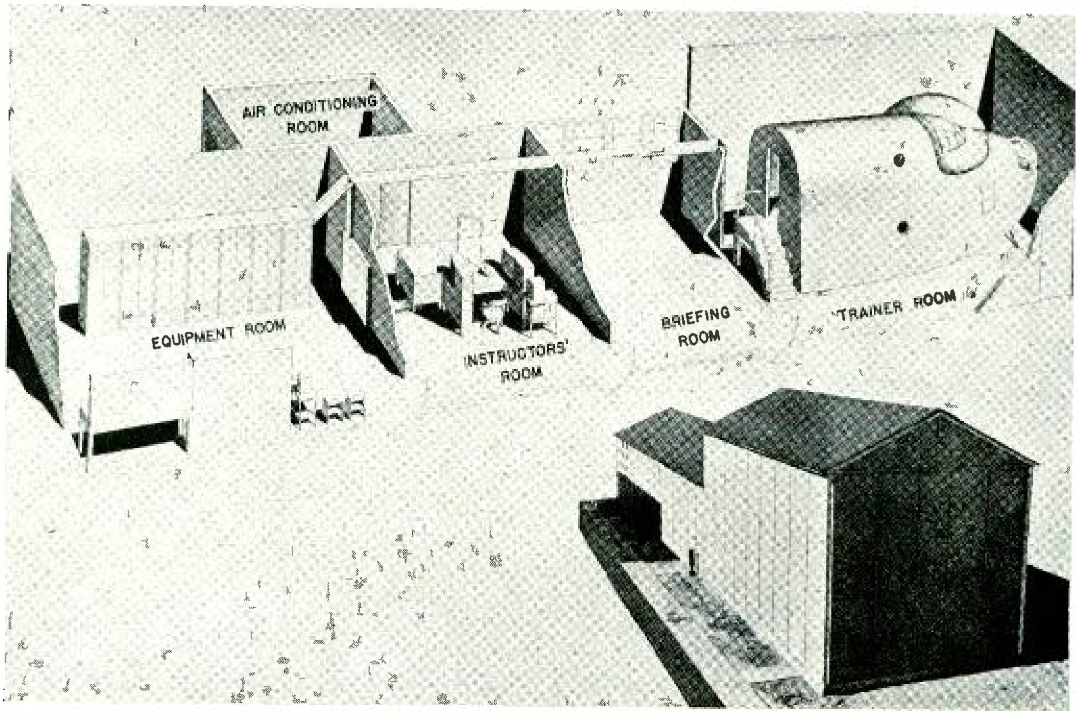
An 88-mm barrage had knocked out the telephone lines of a 5th Division Infantry company somewhere in France, and two of the company's ace trouble-shooters set out to find the break and repair the line.

It was one of those dark nights, the *Army Times* relates, when you find a foxhole only after you fall into it. Each foxhole was like a bathtub filled with water and glue.

Before long the two GI's—Privates Nagel Smith of Bradley, Mont., and Arch Gibson of Mobile, Ala.—were a sticky mess from head to foot. Just as they had found the break and were skinning the wires, a roving guard happened to hear them and challenged them with a businesslike: "Who's there?"

At the limit of his patience, Private Smith sang out: "GI Joe with a wire in each hand trying to tie the damned thing together!"

The surprised sentry had heard what was probably the most unusual answer ever given to a challenge. He let them work on.



Ten Minutes Over the Patuxent River

DEMONSTRATION of the flight crew trainer, described on page 33 of this issue, climaxes two and a half years of a development program which is still continuing. In the early part of 1942 Captain de Florez felt that the time was ripe to build a trainer for the entire crew of a large airplane. The well-known Link Trainer has been used by the Armed Forces for instrument and navigational training. Trainers had also been devised by R. C. Dehmel, the British and others, but none was sufficiently comprehensive to accomplish the purpose Captain de Florez wished to achieve.

Work was started in July, 1942, by a group of circuit development engineers headed by E. J. Kane and R. C. Davis. Their first task was to familiarize themselves with the aerodynamic relations involved and analysis of performance for the engines.

By the early part of 1943, experimental set-ups of the basic features had shown that the project could be carried through, and a mock-up of the control cabin of a PBM-3 was furnished by the Navy. Work proceeded in equipping this model with standard controls and with instruments looking like the actual ones but whose "works" were suitable for operation by artificial electrical means. Between controls and instruments an elaborate electric network was connected. In July, 1943, Captain de Florez was invited to inspect the trainer. After a few minutes at the controls, he was evidently under the illusion of actual flight, and when he finally landed and shut down the engines, he admitted that he had had "quite a workout."

That first model was shipped late in 1943 to the Navy's training center at Banana River, Florida. R. H. Gumley spent the next five months there to make the minor changes which his actual experience on flights indicated.

In the Laboratories the work was handled by telephone circuit engineers in the manner characteristic of telephone developments. Responsibility was centralized in Mr. Davis, since circuit work was the principal problem. He called on the group of apparatus engineers headed by D. H. Gleason for design of components, on the equipment group headed by L. J. Purgett for the assembly of the various elements into an array of steel cabinets and on the power group headed by H. T. Langabeer. Standard telephone technique was followed, and design was as far as possible molded about components available on the market rather than designing of new parts whose construction might delay the project.

Included in the development was complete training equipment for the aircraft radio. This work was handled by F. L. Baulch.

Arrangements for the demonstration at Patuxent River were handled by Lieutenant J. H. Lloyd for the Special Devices Division of the Navy, Lieutenant B. C. Capehart for Naval Air Transport Service, and R. K. Honaman and P. B. Findley for the Laboratories. Careful preparations for the event were made by Ensign Robert Cochran, in charge of the Trainer, and H. J. Kostkos of the Laboratories. Through the courtesy of Naval Air Transport, the inspection party was taken from Washington to Patuxent River and back, and was entertained at lunch at the Officers' Club. Speakers were Commander D. L. Hibbard, Assistant Director of Special Devices Division, Commander Harry R. Canaday of Naval Air Transport at Patuxent River, Mr. Honaman, and Ensign Cochran. The latter explained the various flying controls and instruments, after which each guest was given an opportunity to "fly" the trainer.

Souvenir card given to guests at demonstration of flight crew trainer

Lloyd Espenschied Honored

At the First Annual Conference of the Television Broadcasters Association, December 11 and 12, there were made a number of awards for progress in television, one of which was to Lloyd Espenschied, Research Consultant, "for adapting the coaxial cable to transmitting wide bands of radio frequency suitable for modern television."

[Realizing that any adequate television transmission would require at least a one-million-cycle band, Mr. Espenschied in the 1920's began searching for a wire system which would be capable of transmitting such high frequencies over long distances. This was a daring project for the times, for million-cycle transmission had been considered as exclusively the province of radio. For wire transmission, there was required a structure of reasonable attenuation and well shielded against the pickup of high-frequency noise. Mr. Espenschied and his associates eventually arrived at the idea of a coaxial structure, in which one conductor is cylindrical and encloses the other. That structure, old in itself, had been used for very low frequencies in submarine cables and for radio frequencies as an antenna lead-in. By theoretical studies, backed up by experiment in the Laboratories, it was shown that the coaxial could be used for transmission of a continuous band extending to radio frequencies which could be split into many talking paths or used en bloc for television. By electronic amplifiers, the length of such a system could be extended indefinitely. Thus was born the present coaxial system for television transmission.—Ed.]

Pioneers Add 14,000 Members in 1944

The Telephone Pioneers of America, with fifty-seven chapters throughout the United States and Canada, report an addition of 14,000 new members in 1944. The estimated membership of the entire Association at the end of December, including 12,500 life members, totaled 89,000. The number of Telephone Pioneer life member clubs also increased considerably during the year, and more are in the process of being formed.

Telephone Pioneers Enrolled in Frank B. Jewett Chapter During the Last Half of 1944

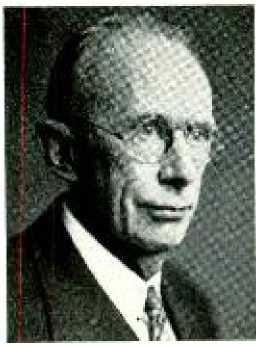
James Abbott, Jr.	O. J. Drost	S. A. Henszey	R. H. Mills	J. L. Sherry
L. G. Abraham	R. C. Eggleston	F. H. Hewitt	H. A. Miloche	L. R. Shropshire
Edward Alenius	H. J. Elschner	J. M. Horne, Jr.	J. W. Moeller	E. F. Smith
Dorothy Angell	O. D. Engstrom	J. E. Johnson	E. R. Morton	G. C. Southworth
Herbert Arlt	E. C. Erickson	V. L. Johnson	Anna Muller	C. A. Sprague
G. E. Atkins	J. R. Erickson	C. J. Johnston	J. R. A. Mulligan	Everett St. John
T. E. Battaglia	H. C. Essig	L. R. Kalmbach*	John Murray	Walter Steinmetz
T. V. Borlund	H. E. Etheridge, Jr.	Marion Kane	J. F. Neill	J. R. Stone
A. E. Bowen†	H. H. Felder	Mae Keefe	L. A. O'Brien	A. R. Thompson
R. G. Bowen	J. G. Ferguson	J. T. Keough	P. S. Olmstead	W. F. Vieth
R. M. Bozorth	Lawrence Ferguson	Helen Kerr	Pauline Osgood	A. C. Walker
F. A. Brooks	R. C. Field	L. A. Kille	Gladys Paret	C. D. Walker
A. F. Cadavero*	John Fierst	R. E. King	J. J. Paris	J. G. Walsh
H. D. Cahill	E. L. Fisher	W. G. Laskey	K. W. Pfleger	H. K. Warnke
James Cameron	W. O. Fullerton	F. B. Llewellyn	D. W. Pitkin	E. F. Watson
P. A. Ciampa	W. J. Gordon	A. V. Loog	G. C. Porter	Markley Wean
R. A. Clarke	R. O. Hagenbuck	Bartholomew Lynch	C. R. Post*	M. A. Weaver
H. E. Coffin	C. D. Hanscom	John Maas	R. K. Potter	C. A. Webber
T. L. Corwin	L. E. Harrison	G. J. MacDonald†	Alfred Quaranta	D. H. Wetherell
G. W. Cowley	Charles Haug	Kathryn McGaughin	E. H. Quoos	David Wheatley*
R. E. Crane	E. J. Hawes	Sallie Mead	F. J. Redmond	I. W. Whiteside
W. J. Crumpton	J. R. Hefele	E. B. Mechling	G. E. Reitter	Wiley Whitney
V. I. Cruser	H. W. Heimbach	T. H. Metzger	Ethel Rispin	F. N. Williamson
J. J. Cusack	A. I. Heitzman	Cornelia Miller	J. E. Ross	William Wynn
C. D. Davidson	J. B. Hennessy		H. C. Rubly	Sylvester Young
M. T. Diaz			G. V. Ryan	Arthur Zitzmann
Agnes Dowd			W. H. Sellew	

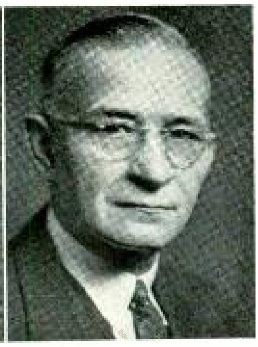
†On Military Leave of Absence.
*Transferred from other Chapters.

Each of these is an organized group of retired Pioneers in a particular area.

The Hospital Visitation Plan, inaugurated in 1944, is progressing well, according to reports received at Association Headquarters in New York. This plan provides for visits by Telephone Pioneers to service men and women from telephone companies, or their sons, daughters or other immediate relatives, who are patients in Government hospitals. Already more than 200 such hospitalized people have been cheered by the Pioneers' visits. The activity also provides reassurance to their relatives to whom reports are made.

When Seaman Elmer Hall of Louisville, Kentucky, fell unconscious while serving on a small Navy vessel in the Pacific, the ship's radioman called the senior medical officer at Honolulu. A stethoscope was put over the sailor's heart and the earpieces put to the microphone. Hundreds of miles away a Navy doctor listened to the weak heartbeats. The diagnosis: an asthmatic attack. Instructions were given and the sailor's life was saved.





DONALD ROSS GEORGE GERRY

Retirements

DONALD ROSS of the Equipment Development Department retired at his own request with a Class A pension on December 31. After receiving his B.S. in Mechanical Engineering from Kansas State College in 1907, Donald Ross spent three years in engineering work in industrial concerns and one year in civil engineering studies at the Missouri School of Mines. He then joined the Inspection Department of the Western Electric Company at Hawthorne, handling engineering complaints. Later he transferred to the Drafting Department on switchboard design and layouts, coming to New York in 1914 where he continued the same type of work.

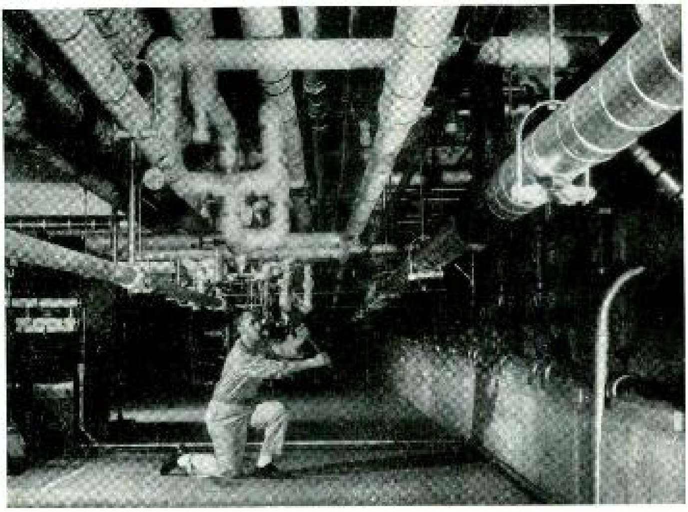
In 1921, Mr. Ross transferred to what is now the equipment development section of the Systems Development Department and became associated with the design and development of frames that were used in the various panel offices which were then being installed, first in New York and later in other cities throughout the United States. More recently he has been concerned with the engineering requirements for switchboard power cabling and floor plan arrangements for the various types of frames used in both the panel and crossbar dial telephone systems, these requirements later becoming Bell System standards.

GEORGE GERRY of the Development Shops Department retired with a Class B pension on December 13. He joined the Engineering Department of the Western Electric Company in 1917 as a sheet-metal worker in the Building and Maintenance Department. Shortly thereafter the sheet-metal group was combined with the Model Shop, the forerunner of our present Development Shops. In addition to the usual run of work passing through the group, Mr. Gerry looks back to two particular projects with which he was concerned—the construction of a diving helmet for underwater telephone work and the fabrication of some of the larger type loudspeakers.

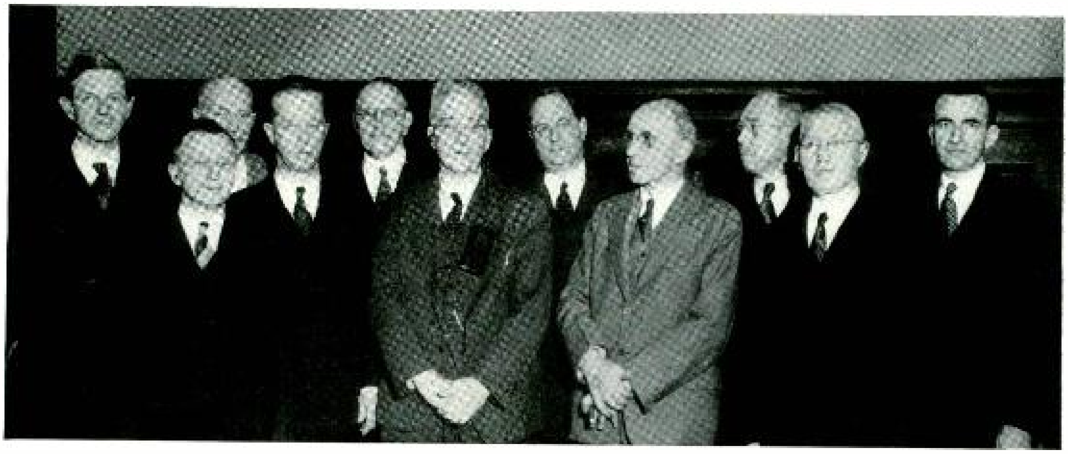
Flying Bombs

In a letter to K. K. Darrow, sent in acknowledgment of a copy of the RECORD containing the article *Electrical Director Helps Bring Down Buzz-Bombs*, Professor S. Chapman of the Imperial College, London, wrote:

"I was much interested in the article on M9 in the BELL LABORATORIES RECORD, and



The main service piping at Murray Hill extends the length of the buildings in the cellars near the outside walls. Risers located in vertical chases in these walls distribute the services to the laboratories above. Vitrified clay drains, shown at the right, are installed at six-foot intervals in the chemical section of the buildings. The cellar ceiling is low to permit reaching the pipes without ladders. N. F. Marinaro is shown working on a trap in one of the main steam lines



Thomas Shaw, whose contributions to telephone development started in the early days of loaded lines, is honored on his fortieth service anniversary. Left to right—R. W. King, H. S. Osborne, John Mills, A. B. Clark, K. S. Johnson, Thomas Shaw, J. J. Pilliod, F. B. Jewett, Lloyd Espenschied, William Fondiller and F. H. Best. R. A. Haislip and R. S. Hoyt attended the luncheon but left before the photograph was taken

indeed in much else in that issue. For nearly two years I have been Deputy Scientific Adviser at the War Office, and was intimately in touch with the battle of the flying bombs; so I was thoroughly familiar with the great help that our Anti-Aircraft Command received from our American allies. The M9 and another U. S. device were of great importance; also there were several American AA batteries on the South Coast. The AA defense has been increasingly successful, and still goes on extremely well against the flying bombs that are air-launched against London.

"But despite all our very good defenses these bombs did grievous damage to London, the effects of which, in overcrowding and discomfort, will take some years to overcome after the war. One fell in our road (in Wimbledon) 200 yards away, demolishing several houses and damaging far more, including our own, which also received damage from two other flying bombs that fell 300 and 350 yards away. The fallen ceilings have been made good only this week, the roof was repaired rather earlier, and temporary repairs made to doors and windows, but we have never had to leave our home. . . .

"The war has laid a very heavy burden on housewives in this country—little domestic help, shopping very difficult and all to be carried home, and much contrivance needed over household feeding. . . . Also our national rationing system has been admirably conceived and administered, so much so that for the working people the war has raised their standard of living; very fortunately so, in view of the great burdens they have so well shouldered. . . . "

Keep the Red Cross at His Side

The President has designated March as Red Cross Month, the period in which its 1945 War Fund will be raised. The Welfare Fund Committee of Bell Laboratories Club will solicit your contribution during March, and when you fill your pledge card you may designate the chapter or branch in your home community to receive your donation. It is desirable that you contribute through the Laboratories so that our participation will compare favorably with other Bell System companies in the Metropolitan Area. If you wish, you may have your contribution deducted from your salary by the Payroll Department.

Paper Salvage

New York City householders are wasting 2,000 tons of waste paper a week by mixing it with garbage or by burning it, according to the WPB-CDVO Salvage Coördinator for New York City. They asked that everyone pay special attention to loose or scrap paper; to keep this clean; and to save it in a small container that can be turned in to the regular weekly salvage collectors. By scrap paper is meant egg cartons, empty boxes, box tops, wrapping paper, envelopes, old circulars and throw-arounds, old calendars and cardboard. Many people have believed that only newspaper was valuable for waste paper salvage.

Obituaries

During recent weeks one retired and four active members of the Laboratories have died: Morris LeBoff who retired last April, on December 31; George N. Saul on December 12; Thomas Glennon on December 21; Charles W. Anderson on December 22; and Charles E. Murphy on January 13.

* * * * *

Mr. LeBoff joined the Engineering Department of the Western Electric Company in 1918 as a machinist. Almost from the very beginning of his employment, Mr. LeBoff was identified with the making of solenoids, transformers and especially toroidal coils which have been used extensively in the rapid growth of transmission networks. From 1936 until the time of his retirement he was a supervisor in charge of a group of men and women engaged in coil work in the New York Development Shops. A photograph of Mr. LeBoff appeared in the Record for May 1944.

* * * * *

Mr. Saul, a member of the Technical Staff in the Switching Development Department, came to West Street in 1920. In World War I he was a member of the 102nd Mobile Ordnance Repair Shop of the 27th Division and served overseas for nearly a year. His first work here was as a laboratory assistant in the toll circuit laboratory. In 1925 he was concerned with the design and development of toll-tandem and toll-switchboard circuits. More recently he was associated with the No. 4 crossbar toll system placed in operation in Philadelphia in 1943. He was particularly concerned with the development of the No. 17C test board, test circuits and toll trunks for this installation. Just prior to his death he had been working on a new toll test board.

Since 1940 Mr. Saul had been taking courses at New York University which would have led to an E.E. degree. Before this he had attended Alfred University in 1914, Cornell in 1915, and had taken, while with the Laboratories, evening courses at Cooper Union, Columbia and the Polytechnic Institute of Brooklyn.

* * * * *

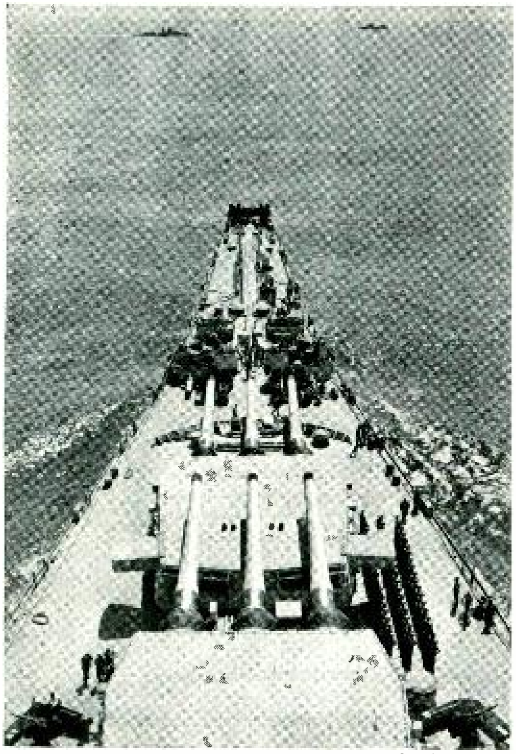
Mr. Glennon and Mr. Murphy were utility service hands with the local service organization of the General Service Department. Mr. Glennon joined the Laboratories in June, 1944, and was stationed in the

G. N. Saul
1897-1944

C. W. Anderson
1895-1944

C. E. Murphy
1899-1945

Thomas Glennon
1899-1944



U. S. Navy Photo

Shown cleaving the Pacific like the head of a giant arrow, this battleship, the Iowa, *is equipped with a Western Electric battle-announcing system, which includes eight transmitting stations,* 294 *loudspeakers and* 31,000 *feet of cable. In addition, it has seven local announcing circuits serving individual sections of the ship. Western Electric sound-powered telephones also go into some of the battleships of this class, including the* Wisconsin *and the* Missouri

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West Street building. Mr. Murphy, assigned to the Graybar-Varick building, joined the Laboratories in August, 1943.

* * * * *

Mr. Anderson joined the Development Shops Department as an Instrument Maker in February, 1942, and worked in the central shop until June of that year. Then he was assigned to the shop on the eighth floor at West Street, and made tools, parts and assemblies required for several war projects.

Holiday Traffic Up, Service Better

Operating staffs at the switchboards throughout the Nation did a magnificent job on Christmas Eve and Christmas Day in handling one of the heaviest floods of holiday traffic encountered.

Local traffic assumed tremendous proportions in many places and toll board traffic was 6 per cent higher in 1944 than in 1943. Nonetheless, service was better, generally speaking, than on the previous Christmas.

Posted delays, both in the number of circuit groups involved and in duration, were a little less than on Christmas, 1943, despite the fact that about three-fourths of the Pacific Company circuits and one-fourth of the Long Lines circuits terminating in Washington and Oregon were out of service because of ice conditions.

Completion of holiday calls was improved, being some 2.4 per cent higher than the previous Christmas. Customer acceptance of the service was very good.

Overseas messages from all points on Christmas Day totaled 1,147—a 6 per cent increase over last year. Completion of these calls was 86.1 per cent, as compared to 88.8 per cent on Christmas Day, 1943. The 1,147 Christmas Day messages compare with 340 messages handled on an average business day in December.

The Scientists

Dedicated to Doctors of Philosophy

Who are the restless Ph.D.'s,
Those minds behind our phone,
Who grasp the raveled skein of thought
As dogs will grab a bone?

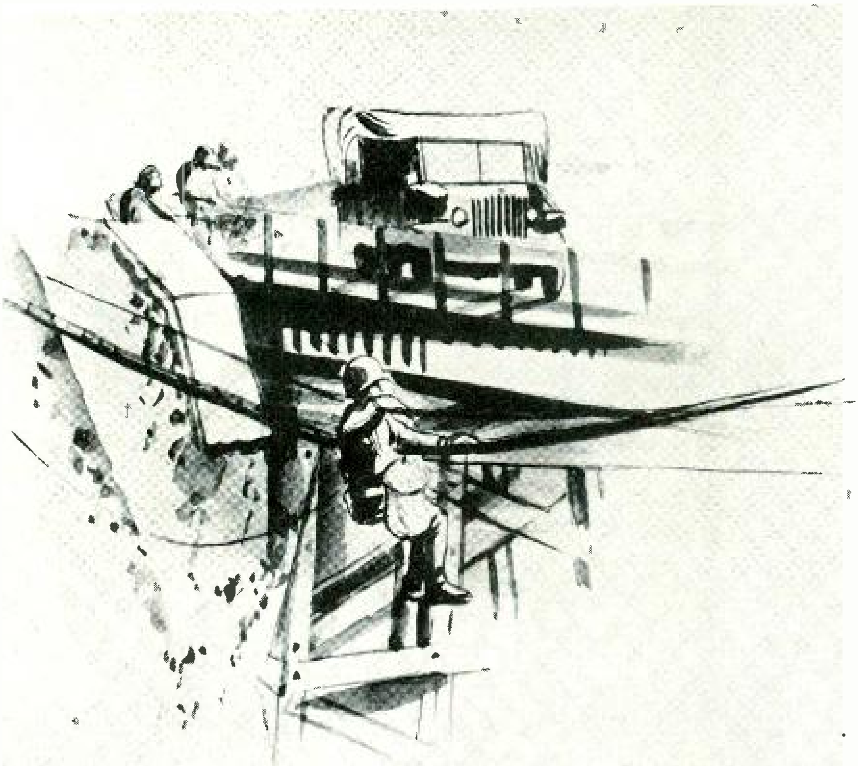
They are such men who, sleeping, dream
The strangest things by night,
Who glimpse the weirdest formulas
And wing them in their flight.

With ruthless fact and figure, then
They shape the shadowed thought
Until a startled world may see
The dream in matter wrought.

Who knows what holds that careless nap,
What wonders yet may chance,
For men that spy with inner eye
Ballistics in a trance?

For night and day, 'tis theirs to roam
The shores of unknown seas
In search of truth which lesser men
Oft leave to Ph.D.'s.

M. Brotherton.



War's Hunger for Telephone Plant Revealed in Tales Told by Splicers in Battle Zone

By RALPH MOONEY
Information, A T & T

IF ANYONE wonders why Western Electric's tremendous production must be devoted almost altogether to the needs of the Armed Forces, there are some Bell telephone men around who can give an answer from recent first-hand experience in France and Belgium.

Thirty cable splicers who volunteered for three months' special service in Europe with the United States Army have returned to this country. And each man, in reporting his experiences, tells of bombardment damage, sabotage and other contingencies that swallow up more and still more equipment in the war zones.

For instance, one of the returned splicers mentions a shattered cable along the railroad from Le Mans to Chartres. He estimates that it was necessary in five weeks of restoration work to cut in about 33,000 feet of cable and wipe more than 300 joints.

This was just a small cable, although important to the Army Service of Supply. Only a fifty-mile stretch of right-of-way was covered. But hundreds of similar jobs were completed by our splicers, and thousands by the Signal Companies of the Allied Armies.

At present some 1,500,000 applications for telephone service are being held by Bell System companies because of lack of equipment. Mountains of cable, telephones, wire and central-office equipment are being manufactured, but for a glimpse of how and where some of it is going to war, read this

The Germans used an acid salt solution to sabotage cables

excerpt from the splicer's report of a job on the London-Paris cable:

". . . the repeater stations and cables were blown all to hell. We made twenty-two splices in one-half mile. . . .

"In some places the French Forces of the Interior had cut them—mostly at the cable markings which were loading or balance splices. We had to cut these out and cut in a new piece just like the old to keep the loading straight. Our next job was at a Calais repeater station where the British were to meet us with cross-channel coaxial."

And this, from a team of Bell splicers: "The first job we had was to take a sleeve off at a German repeater station. After this we were assigned to a cable which had been damaged. In about one mile it had been hit with an earth borer in twenty to twenty-five places."

Also: " . . . the Boche destroyed the cable at Thore and we had to make up new cable heads, working with German material. One night while we were sleeping two of the cables were cut by saboteurs and we had a job to do all over again."

The fact that the military authorities flew these volunteers to Europe makes it obvious that they were urgently needed. The importance of their work in France is reflected in such reports as this from one of the men:

"One Sunday night we were called out on trouble on the main cable to Paris. It was a nasty night, I must say. The trouble could be almost anywhere along the 140 miles of cable between Le Mans and Paris. We located it and one hundred feet of 150-quad cable had to be cut in. As soon as this was done, another trouble appeared which was also located and sixty feet more of similar cable had to be cut in.

"The colonel seemed awfully pleased that this job was finished, and he expressed his appreciation, and said he didn't know what the outcome would have been if we hadn't been there."

Much repair of intentional or casual damage to German cable was necessary. For these repairs the men had to improvise methods of finding the buried cable since the Germans had been at pains to keep its location secret:

"The work was a great deal different from at home as we had to establish our own

Two flashlights per splice for two hours with two feet of mud and water under them

feet-per-ohm on all cables beside locating the route of the cables. This was especially difficult due to quick temperature changes. We had no prints or layouts, no load-coil resistances, or anything else to go by. We made our own induction wheel for verifying the route of the cable. And the cable we were working on was sabotaged while we were still on it.

"We found our GI guard very observant and much interested. In fact, we had him so he could loop trouble by himself before we left."

From another report: "The French loading pot can be repaired in the field. The cover is removed, compound removed, and the brass case is opened. The coils are then simply buzzed out and, if known, the loads put on the proper pairs or quads. If not known, a resistance-loop test can be made."

And still another: "The 14 quads of cross-channel cable had trouble on for three or four days and the GI's had been working on it, and had had very little luck as the cable was hard to find. One of the team leaders finally asked me to help them as we had been waiting for transportation. I had the biggest thrill of my whole telephone cable splicing experience on finding the actual trouble in one-half hour.

"We soon had a piece of cable, although it was not of standard size. We cut in a new piece with two flashlights to a splice and two feet of mud and water under us. The complete job only took us a little over two hours. In doing it I earned the respect of some of the finest kids—I guess I'd better say men—I have ever met."

The Bell splicers found the German military cables to be a good set-up. Several reports corroborate this. For instance: "All the cables in our territory were tape-armored and buried two to three feet deep. Composition was 4 quad, 7 quad and 10 quad with conductors from 13 to 19 gauge. The largest one was a 56-quad special cable."

One sabotage method used by the Germans, probably while making ready to retreat, was to push down a sharp probe through the soil, through which they would inject an acid salt solution into the cable. The object was to eat away the conductors to a breaking point. However, our men found them eaten badly but not severed in most cases. At other points the Germans had used hand grenades.

Storm conditions while flying provided the first thrill for the traveling splicers. One or two of the men relate that their air transports were grounded for a period, and others tell of pilots having difficulty in landing. After arrival in Britain, the contingent was assembled in London for further processing by the Army for a few days. This was at the height of the buzz-bomb attack. All the Bell men heard robots explode, a few at distances entirely too short for comfort. When they got across the channel, some worked in heavily mined areas. One man, driving to work in an Army truck, missed a sign that read, "This road not checked for mines." In a stretch where it was too narrow to turn back, he noticed mine detonators above the road surface. He had to zig-zag around the

Seven men dive for shelter behind cable cart to evade sniper's bullets mines until, at the edge of a bomb crater, he managed to run and zig-zag out again. The weather was cold, he says, but he found himself dripping sweat as he regained safe territory.

One man tells of being shot at by a sniper. His own words: "We first went up in Belgium and repaired a cable that had been blown up with some bridges. After completing that mission we were sent back near Calais.

"There we cut in short pieces across bomb craters. One of my biggest scares and thrills was when we were shot at by a sniper twice. I am still trying to figure how seven men got behind one small cable cart."

Another man tells of a German soldier, from an isolated force, who wandered up to an American supply detachment and offered to trade a Luger pistol for cigarettes or food. Many such men, according to this splicer, contrived to remain at large after the main Allied Armies had passed. They were in far more danger from French Forces of the Interior than from our men who for the time being elected to disregard ineffectual troops.

At some points French cablemen appeared to help with the restoration work. They are characterized as "swell Joes." And one report says: "We had the pleasure of working with two French testmen who were very friendly and grateful that we had come over to do the job. They seemed amazed at the amount of work accomplished in a single day. This was our job. So we set out to prove that all the first-class splicers are not in France. I say this because the French think they are the best splicers in the world."

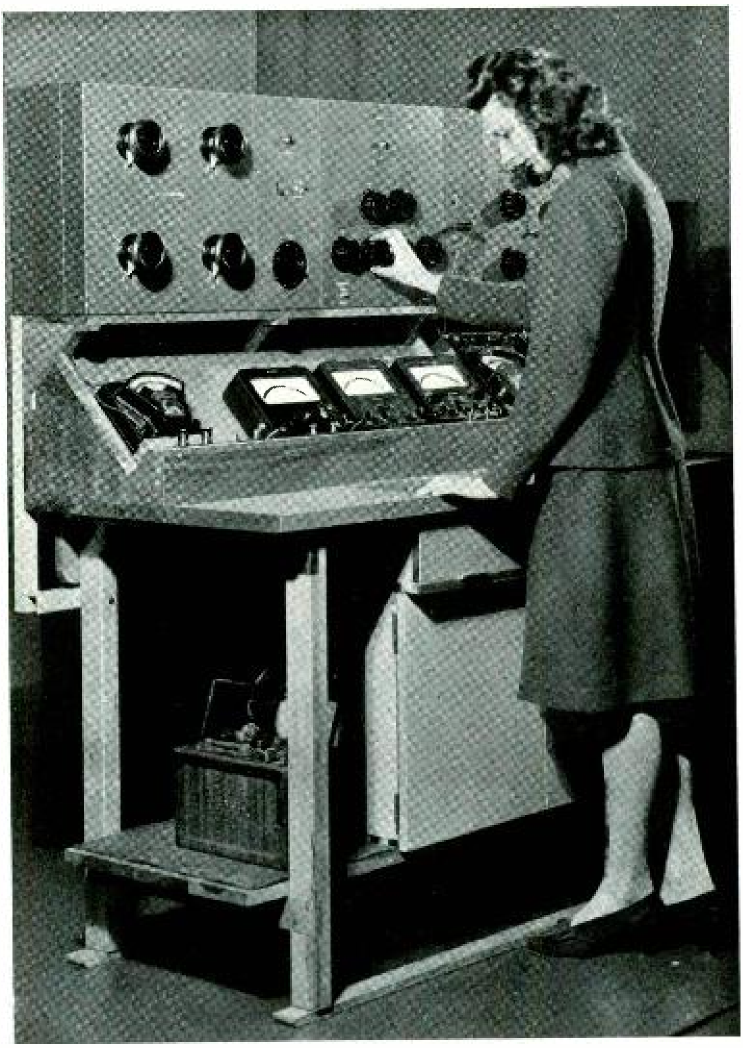
All of the splicers commend the speed with which they were "processed" at Washington, and the Army's efficient arrangements that were made for transporting them to Europe and back again.

[The Bell cable splicers whose reports are summarized here were flown to the European war theater by the Army who asked them to volunteer for three months "arduous duty." Wearing arm bands and army uniforms, they worked side-by-side with Signal Corps personnel. The Army's call for volunteers was issued to plant men in the seven easternmost Bell System companies. Response was so great that quotas had to be set because only thirty men were required.]

Bound copies of Volume 22 of the RECORD (*September*, 1943, *to December*, 1944) *will be available in the near future* — $2.75, *foreign postage* 25 *cents additional. Remittances should be addressed to Bell Laboratories Record*, 463 *West Street*, *New York* 14. *A separate index to Volume 22 is now available and may be obtained upon request*

A Meter Test Set

By MRS. N. M. GILBERT
Electrical Measurements



WAR activities have greatly augmented the work carried on in our outlying laboratories, and one of the results has been a large increase in the number of electrical meters in use in these Laboratories. To avoid the delay and inconvenience of returning the meters periodically to West Street for calibration, which is particularly inconvenient with the reduced transportation, a meter test set has been designed that permits all ordinary voltmeters and ammeters to be quickly calibrated with engineering accuracy. For voltmeters, either a-c or d-c, the range extends to 750 volts; for a-c ammeters it extends to 100 amperes; and for d-c ammeters, to 50 amperes. The first of these units is already in use at the Whippany laboratory.

As shown in the photograph at the head of this article, the test set consists of a laboratory type table with control panels mounted above the rear edge, with standard meters arranged along an inclined shelf beneath the control panels, and with horizontal space for placing the meters under test. Beneath the top, and visible through plate glass windows, is a high-voltage compartment used for voltages greater than 150. It is equipped with an a-c and a d-c standard voltmeter with space between them for the meter under test. Beneath this compartment are batteries for the d-c voltage and milliampere tests, and on the shelf to the left is a 6-volt storage battery for d-c ammeter calibration. Power for all a-c calibration is taken from the 115-volt, 60-cycle, commercial supply.

A-c calibrations are controlled from the panel at the extreme right and the narrow jack panel immediately to the left of it, which may be seen in Figure 2. Associated with these panels are three standard meters: a voltmeter with a 0 to 1.5 and a 0 to 3 volts range and an ammeter with ranges from 0 to 2.5 and from 0 to 5 amperes, which are on the inclined shelf directly beneath the control panel, and a voltmeter with ranges to 300 and 750 volts, in the high-voltage compartment. All are Weston meters, the voltmeters being model 341, and the ammeter, model 370.

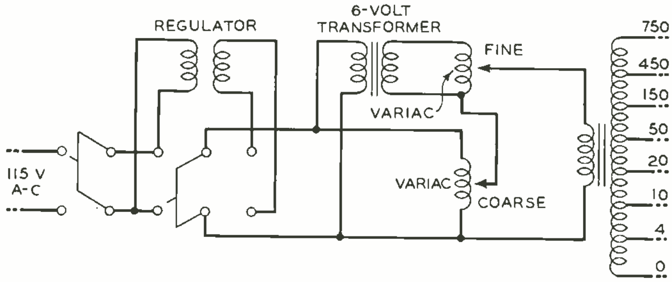


Fig. 1—Power supply circuit for a-c calibrations

Control for all a-c measurements is through two variacs in the primary circuit of a power transformer that supplies seven testing voltages from its tapped secondary. The arrangement is shown in Figure 1. A voltage regulator, arranged to be cut into or out of the circuit, is normally used for all voltage calibrations and for current calibrations up to thirty amperes. Because of its limited capacity, it must be cut out of the circuit for larger currents. One variac gives coarse control of voltage, the other, fine. Connections are taken from the tapped secondary for both voltage and current calibrations through selecting switches. After a range selection has been made, control is determined by adjusting the variacs.

For a-c voltage calibrations the circuit is as shown in Figure 3. The upper left dial on the a-c panel controls the two brushes marked A and B at the left to select the desired range. The brushes move together, with B selecting either the 450 or 750-volt transformer tap, for a high-voltage calibration, and A selecting for all other voltages. Above 1.5 volts, the 3-volt winding of the standard is used, but a chain of accurately calibrated multiplier resistances connected in series with it permits the proper range to be selected by the plug and jacks on the narrow panel at the left of the control panel. After the proper voltage tap and the range of the standard has been selected, the voltage is adjusted to the proper value by the variacs, controlled by the two dials at the bottom of the panel.

For a-c current measurements, the circuit is as shown in Figure 4. The upper central and upper right dials on the control panel are used. The upper right dial selects a transformer tap that will provide the desired amount of current, while the upper central dial, controlling the two brushes C

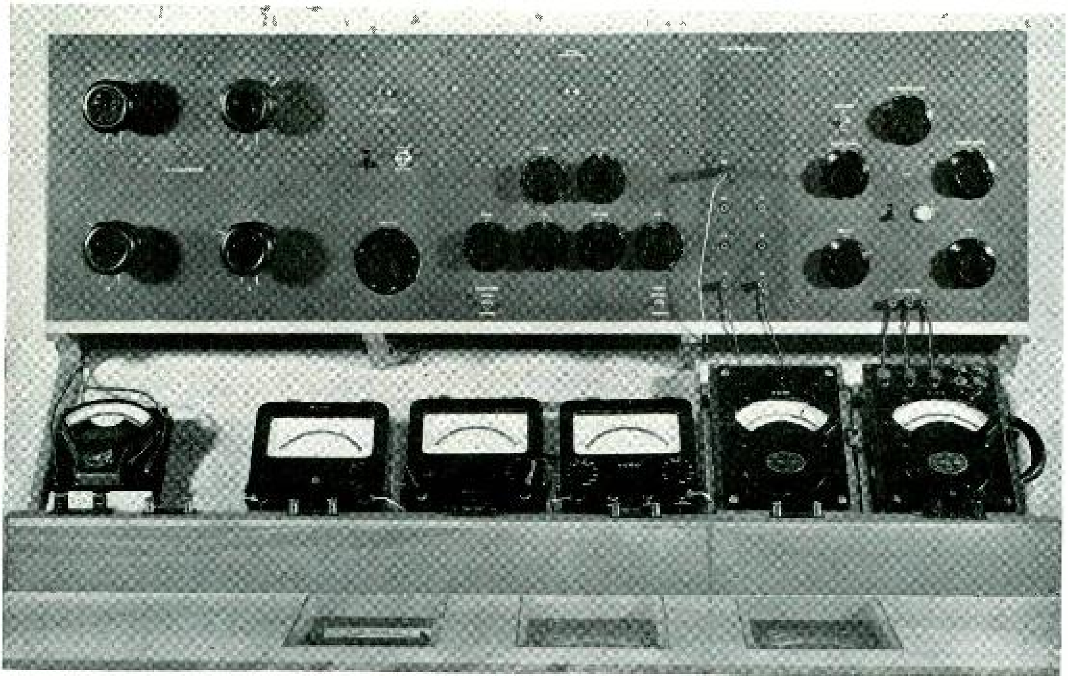


Fig. 2—Front view of test set showing control panels and standard meters

and D, selects the proper range on the standard ammeter. For either 2.5 or 5 amperes, the C brush makes contact directly to one of the two meter windings, but for all higher currents, it makes connection to a tapped current transformer with a 5-ampere secondary.

For calibrating d-c voltmeters, and d-c ammeters up to 200 milliamperes, a range switch and two potentiometers are employed in conjunction with four batteries: a 3-volt battery with a tap at 1.5 volts; a 45-volt battery not tapped; a 180-volt battery with taps at each 22.5 volts; and a 540-volt battery with taps at every 135 volts. The range switch is controlled by the upper left dial of the third panel from the right of Figure 2, and the potentiometers are controlled by the two right-hand dials at the bottom of the panel. The standard meters employed, all Weston Model 622, are: a voltmeter in the high-voltage compartment for measuring voltages above 150; a similar meter, but with seven ranges extending from 1.5 to 150; a millivoltmeter with four ranges from 2 to 2,000 millivolts; and a milliammeter with four ranges from .2 to 200 milliamperes.

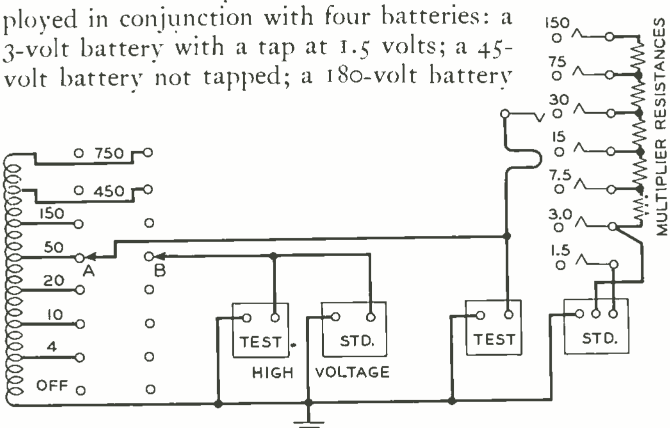


Fig. 3—Circuit for a-c voltage calibrations

In making a test, the range switch is turned to the proper position for the meter to be calibrated, thus making a connection to the proper standard and also to the proper battery combination. The range switch on the standard meter is also turned to the proper position. The voltage applied to the meter is then controlled by two potentiometers. These potentiometers, connected in series to give coarse and fine adjustment, will have been connected across either the 3 or 45-volt battery by the range switch. For voltages above 40, other batteries are connected in series with the potentiometer.

For calibrations in the high-voltage compartment, the circuit is as shown in Figure 5. Voltage adjustment is secured for the most part by the two dials at the lower left of Figure 2. One, marked x135 and connected to the 540-volt battery, gives 135 volts per step, while the other, marked x22 and connected to the 180-volt battery, gives 22.5 volts per step.

For voltages from 2 to 150, the 150-volt meter on the inclined shelf is selected, and either of two circuit arrangements is used. One, employed for voltages from 40 to 150, is like Figure 5 except that the 540-volt battery is out of the circuit. For the other, used with voltages from 2 to 40, both the 540 and 180-volt batteries are out of the circuit. For either of these circuits a switch permits reversing the connections to the meter under test.

For measurements below 2 volts, the millivoltmeter is used, and the circuit is as shown in Figure 6. The resistance marked R has a different value for each of the three possible ranges using this test circuit, 0 for the 2-volt range, 135 ohms for the 200-millivolt range, and 1,350 ohms for the 2,000-millivolt range. Only the 3-volt battery is used, and connection is made to it through the upper right dial. This is normally kept in the maximum, or x1, position,

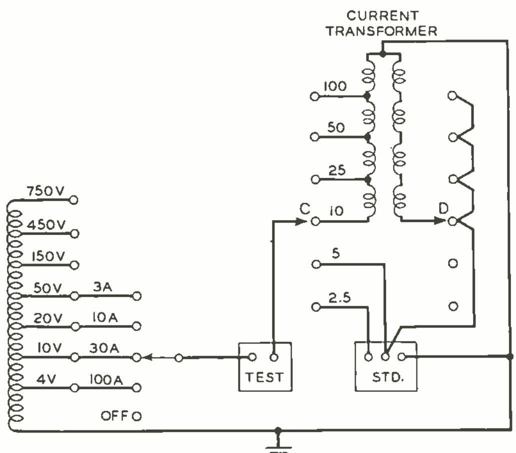


Fig. 4—Circuit for a-c current calibrations

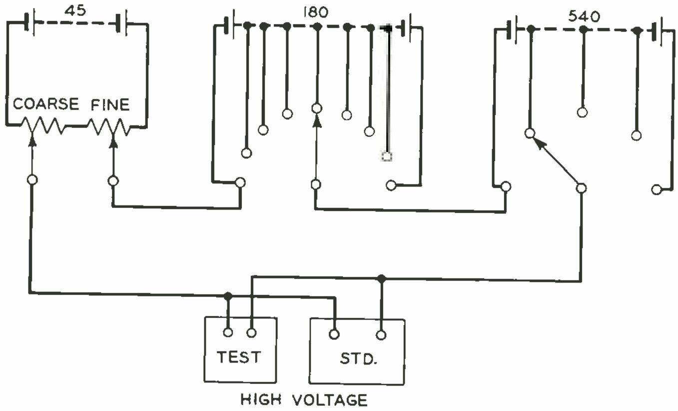


Fig. 5—Circuit for measuring d-c voltages above 150

but a half voltage reading may be obtained by turning it to x1/2.

For milliampere calibrations, the circuit is the same as Figure 6, but with a switch included to permit the connection to the meter under test to be reversed. Four milliampere points are marked on the range switch: MA-LOW, for currents up to 1 ma;

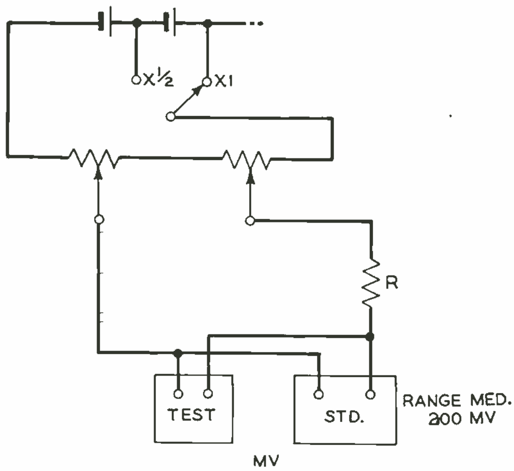


Fig. 6—Circuit for millivoltmeter calibration

MA-MED, for currents from 1 to 10 ma; MA-HIGH (2V), for currents from 10 to 100 ma; and MA-HIGH (40V), for currents from 100 to 200 milliamperes. The circuit for the latter point differs from Figure 6 in using the 45-volt battery.

For checking meters at currents greater than 200 ma, a 6-volt storage battery is used arranged as shown in Figure 7. The shunt is a Weston rotary type controlled by the dial on a narrow panel second from the left. With this dial, any of six shunts—1, 2, 5, 10, 20, or 50—may be selected. The potentiometer and series resistances are controlled by the four dials on the left-hand panel. Since compact rheostats with high enough resistance to give fine control for the lower current ranges and capable of carrying the larger values of current were not available, an interlocking mechanism was designed to prevent any combination of settings that would endanger any one of the rheostats. This is shown in Figure 8. Each rheostat has a different current capacity, and the winding of the lowest-valued resistance, the last in the chain, has a tapered winding. The linkage is arranged so that a rheostat is locked in its OUT position before settings of the others can be made that would endanger it. With this arrangement, adequate adjustment is available over the entire range without overheating any of the rheostats.

Besides these various controls used for the actual calibrations, there are pilot lamps to

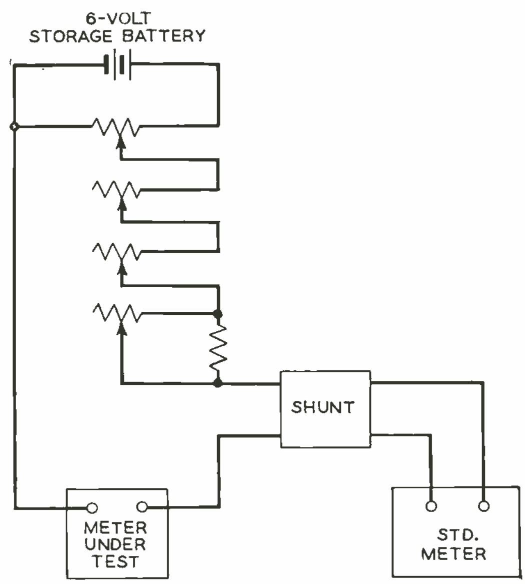


Fig. 7—Circuit for d-c calibrations for currents that are greater than 200 ma

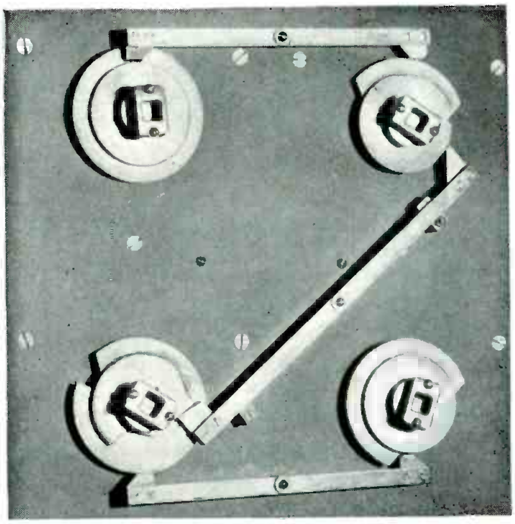


Fig. 8—Interlocking linkage on current control rheostats to prevent damage

indicate when power is on various circuits, and switches for opening or reversing various circuits. All circuits are completely fused for protection, and the connections between batteries are carried through door switches so that, when the cabinet doors are opened, not more than three 45-volt batteries are connected together.

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Signal Corps Photo

Two American soldiers of a signal construction company repair damage done to communications lines during Jap night raid on an island in the South Pacific

A High-Gain Coaxial Antenna

By ARNOLD B. BAILEY
Radio Development

RADIO waves travel in all directions from a straight antenna except in the direction of its axis. They behave much like light radiated from a glowing wire. There is some radiation in all directions, but the amount decreases as the angle increases from the plane perpendicular to the wire, where the radiation is greatest. When the length of the antenna is a half wave at the radiated frequency, the radiation pattern is in the form of a doughnut with the diameter of its hole reduced to zero, as indicated in Figure 1. With the antenna placed vertically as shown at A, Figure 1, the electric waves will be vertically polarized, and their strength in a horizontal plane will be equal in all directions as indicated by the polar diagram at the right. If the same antenna is placed horizontally, on the other hand, as shown at B, the waves will be horizontally polarized, and there will be no substantial radiation along the axis of the antenna, and maximum radiation at right angles to the antenna. The distribution in the horizontal plane would be as shown at the right. If the radiated field strength from the vertical antenna is represented by E, the maximum field strength from the horizontal antenna, which is that at right angles to its axis, will also be E.

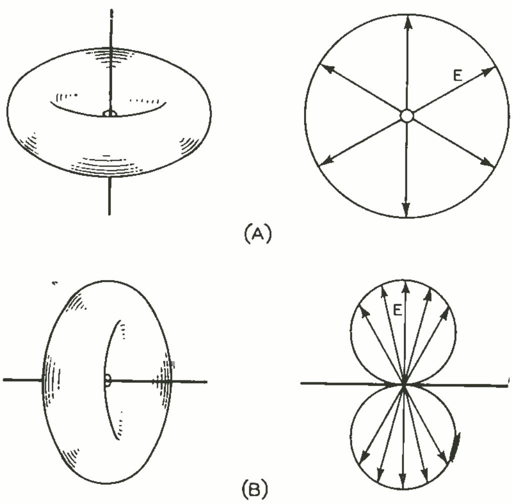

Fig. 1—The radiation pattern from a vertical dipole is in the form of a doughnut, as shown at the left at A. In the horizontal plane, the pattern is thus circular, as shown at the right. When the dipole is in a horizontal plane, as at B, the horizontal radiation pattern of the antenna is as shown at the right

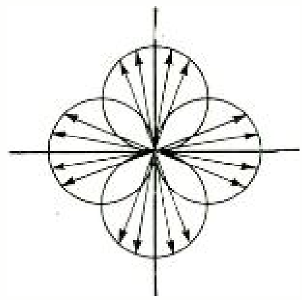

Fig. 2 — The radiation pattern in a horizontal plane for two crossed horizontal dipoles

Since a directional characteristic like that at B is generally undesirable when uniform coverage is desired, it is common practice with horizontally polarized systems to employ two horizontal antennas crossed at right angles and fed in quadrature. The distribution pattern for one antenna of a pair then falls in the areas of low radiation of the other, as shown in Figure 2. The combined pattern for the pair of antennas is approximately a circle with a radius equal to the diameter of the individual circles of Figure 2. If each antenna of the crossed pair received the same amount of power as the individual antennas of Figure 1, the field strength in all directions in the horizontal plane would thus be E as in Figure 1A. Since only half the power from the radio transmitter is supplied to each antenna of the crossed pair, however, the radiated power in the horizontal plane from the pair is only half that of the single vertical antenna, and the field strength becomes $E/\sqrt{2}$ or .707E. The crossed-pair antenna is thus 3 db less efficient in the horizontal plane than the vertical dipole.

When a transmitting antenna is to be used for communicating to vehicles carrying whip-type antennas, a vertical transmitting antenna gives considerably better results because of the vertical polarization of the waves. For vehicular service, therefore, a vertical antenna is preferable even when the doubling of the power described above is not considered.

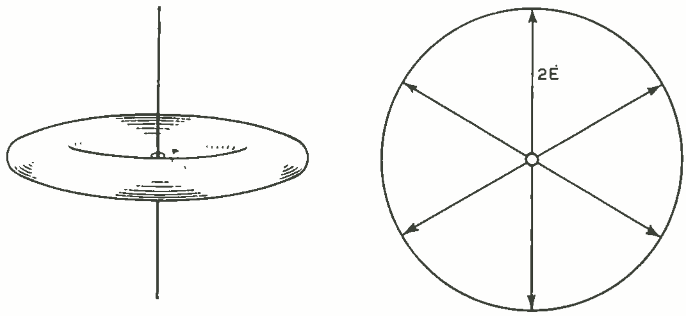

Fig. 3—With two or more vertical dipoles mounted one above the other along a vertical axis, the doughnut of Figure 1A becomes flattened, as shown at the left, but the circular pattern in the horizontal plane remains, as shown at the right

For most applications, it is only the radiation in the horizontal plane that is usable. With either the vertical dipole or the crossed horizontal pair, however, there is a considerable amount of radiation at high and low angles that serves no useful purpose. It has been known for a long time, however, that the radiation in the horizontal plane can be increased, and that in other directions decreased, by mounting two or more in-phase antennas one above the other along a common vertical axis. Each of the antennas then contributes to the radiation in the horizontal plane, and their combined effect decreases the power radiated in other directions. In effect, the doughnut is flattened out and increased in diameter as shown in Figure 3.

Two or more pairs of antennas of the crossed type placed one above the other are employed with good effect at the present time, but greater power in the horizontal plane is possible by placing two or more vertical antennas in an equivalent array because of the facts discussed above. With either type, however, the supporting structures and the feed lines to the antennas may affect the radiation pattern and prevent the full theoretical gains from being obtained. If some method could be devised of avoiding the effects of the supporting structure and feed lines, the full value of the multiple structure could be realized.

In 1941 the Laboratories developed a vertical antenna array that meets these requirements in a very practical manner. It consists essentially of four Western Electric 51A coaxial antennas mounted one above the other in a continuous structure. The 51A is a variant of the widely used vertical coaxial antenna developed by the Laboratories some years ago, which incorporates features that facilitate feeding a multiple array without affecting the radiation pattern.

In a commonly used form the 51A antenna consists of a grounded metal pipe, such as a flagpole, that supports the antenna and serves as the outer conductor of the coaxial feeder. The inner conductor consists of a rod running up the center of the pipe and supported by insulating bushings that insulate it from the

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pipe. The upper end of a metal sleeve somewhat larger in diameter than the pipe is connected both electrically and mechanically to the pipe at a distance one quarter wave-length down from the top. This sleeve is also made one quarter wave-length long, and the central conductor is tapped to the inside of the sleeve through an opening in the pipe. The sleeve and the pipe section immediately above it form a half wave dipole. The inner surface of the sleeve and that section of the outer surface of the pipe it overlaps act as a quarter wave-length matching section between the coaxial feeder and the lower end of the sleeve. As a result, there is high potential both at the bottom of the sleeve and the top of the pipe, and relatively low potential at the common junction of the pipe and sleeve. Furthermore, the supporting pole is effectively isolated from the radiating structure, thus giving optimum conditions for effective radiation.

The method of adapting this type of antenna to a four-element radiator is shown in Figure 4. A metal supporting pipe over two wave-lengths long has four quarter wave-length sleeves attached to it with a quarter wave-length between the sleeves and with a quarter wave-length from the top of the top sleeve to the top of the pipe. The manner of feeding energy to this structure can be varied to meet particular conditions. In the form shown in Figure 4, four coaxial cables are carried up the inside of the pipe, and the central conductor of each coaxial line is connected to the inner surface of one of the sleeves through an opening in the pipe as with the 51A coaxial antenna. The outer conductors of the coaxials are connected to the pipe opposite the sleeve to which their central conductors are connected. The exact location of the four points of connection is a matter of impedance matching and efficient power transfer. The four coaxial cables are brought out near the bottom of the pipe and connected to the supply circuit from the transmitter. The phases at the points of attachment to the sleeves should all be alike, and this is brought about either by making all the coaxials of the same length or by other convenient means.

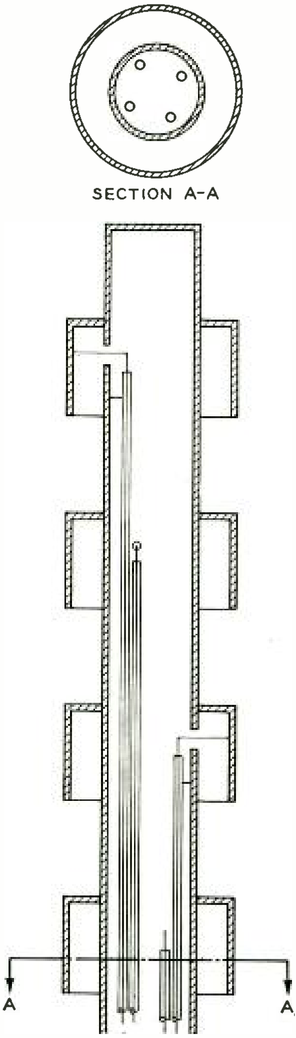

Fig. 4—Four-unit array of vertical dipoles

With such a coaxial structure, the full effect of multiple units is realized. There is a still further increase in radiated power, however, because the four units form a continuous structure. With a single isolated antenna, the current at the ends is zero because of the infinite impedance at these points. When an array of antennas is continuous, however, the impedance at the ends of each unit is not infinite, and some current exists over the entire length of the array except at the top of the top unit and the bottom of the bottom unit. With the array shown in Figure 4, therefore, there is an additional useful power gain because of these conditions.

To attain the full advantage of such stacked arrays in practice, just as in the case of any antenna, their site must be carefully selected, and should preferably be at a point well elevated above the surrounding terrain.