Distinguished Service Medal awarded in the name of the President by Gen. Pershing to Lieut. Col. Krumm for "exceptionally meritorious and distinguished services," due to "masterful ability and exact scientific knowledge"

Lieut. Colonel Louis R. Krumm

The famous French decoration, the Legion of Honor, conferred upon Lieut. Col. Krumm and establishing him among the few American officers who have been admitted as Chevaliers to the century-old order founded by Napoleon

The Authors of Wireless in the A. E. F.

Colonel Krumm is best known to wireless men as Chief Radio Inspector, Bureau of Navigation, Department of Commerce, a position which he has held since 1912. He has degrees of mechanical and electrical engineering from Ohio State University and for seven years served as an electrical engineer, Signal Corps. He was commissioned a reserve Captain in this branch of the service in May, 1917, and within three months was promoted to Major, sailing for France, Sept. 27, 1917. His elevation to the rank of Lieutenant Colonel preceded the Armistice by two weeks, recognition of efficient direction of the Radio Division during the entire term of his service in the A. E. F.

Captain Willis H. Taylor, Jr.

Captain Taylor, a graduate mechanical engineer of Stevens, received his reserve officer's commission as 1st Lieutenant, Signal Corps, two months after war was declared. For six months he was assigned to recruiting for the radio branch, going overseas in December, 1917. Four months later he became assistant chief of the Radio Division, A. E. F., and thirteen months after his enlistment was promoted to the rank of Captain. General Pershing mentioned him in a citation for "exceptional and meritorious services" as the officer responsible for the co-ordination of the work of the other Sections in the A. E. F. and maintenance of liaison with the Radio Division at Washington

Wireless in the A. E. F.

First Authentic Account of the Organization of the Radio Division of the Signal Corps and an Inside View of the Great Obstacles which Americans Had to Overcome

By Lieut. Col. L. R. Krumm
Officer in Charge Radio Division, Signal Corps, American Expeditionary Force
and Capt. Willis H. Taylor, Jr.
Co-ordination Officer, Radio Division, Signal Corps, A. E. F.

IT HAS been a commonplace saying in all articles relating achievements of the Great World War that it was a contest of science and skill.

In no branch of an army's activities is this better exemplified than in the utilization of the wireless method of communication. Thus the prepartion of articles recounting the work of the U. S. Army Signal Corps and its use of radio telegraphy and telephony for military purposes has presented the problem of selection from superabundance, leaving the authors confronted by the difficulty of picking out from the mass of material available those things which will best reflect the magnitude of the task and its accomplishment. In this and the succeeding articles of the series there will be set down without embellishment those historical and technical facts which appear to be of most interest. not alone to the radio profession but also to the general public.

The Authors in the headquarters of the Radio Division at Tours, France

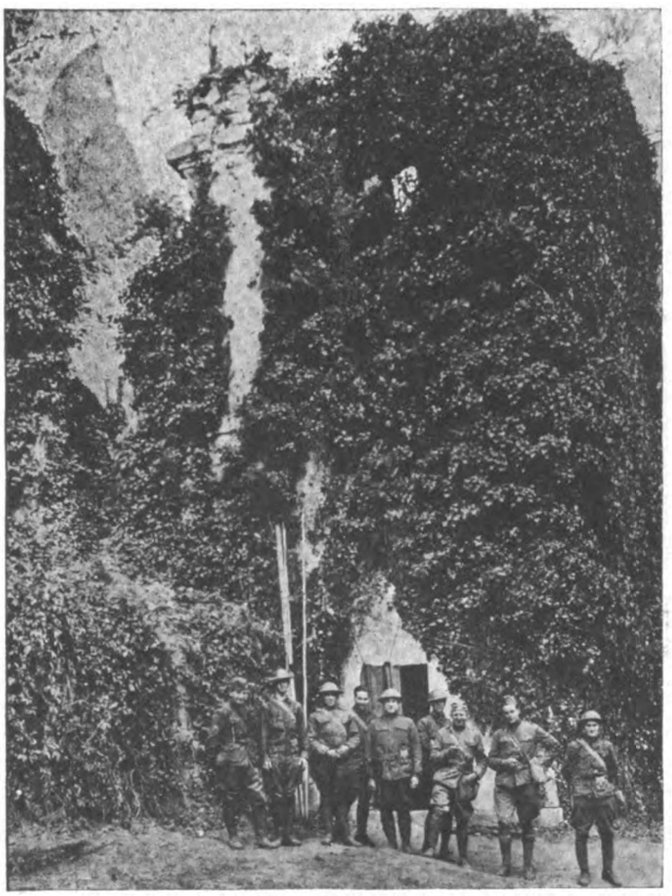
The absolute unpreparedness of the American Army for a war of the magnitude of this one is a matter of universal knowledge; nowhere was it better indicated than in the radio equipment and personnel available to the Signal Corps when this country entered the war. Only two types of military radio equipment had been developed and put in use; these were the ¼ kw. 500 cycle quenched spark pack set, adapted to be transported on mules and provided with a hand driven generator, and a 2 kw. 500 cycle quenched spark automobile set. Both were fairly good equipments of their types, quite satisfactory for warfare such as might be encountered on the Mexican border. Unfortunately neither of these sets was suitable for use in the European war, so that it may be said that the U. S. Army, at the time of the declaration of war against Germany, had no suitable radio equipment for its signalling troops. This was demonstrated. Some of these sets were sent to France, but were never used for transmission during operations. Practically all the radio equipment used by the American Expeditionary Forces was of French manufacture, for the development and production of equivalent material in the United States on a quantity basis was not accomplished until about the time the armistice was signed.

It is interesting to note that after the armistice, an effort was made to utilize one of the pre-war 2 kw. spark tractor sets at Spa, Belgium, to provide communication for the American section of the Armistice Commission which had its headquarters at that point, but its use caused such interference with the undamped wave sets of the stations of the other allied armies as to make the American army decidedly unpopular from a radio standpoint. The station had to be replaced by an undamped wave set, the sharper turning of which permitted the simultaneous operation of the different sets in that vicinity. Spark sets having more than 100 watts transformer input were decidedly *de trop* with the Allied Armies in France, and the extensive use of vacuum tube undamped wave transmitters—even with the very front line troops—was decidedly contrary to the previous practices or principles of our Signal Corps. In a later article a detailed description of these sets will be given; at this time it will be sufficient to say that the suitability of this type of equipment to meet the trying conditions of war communication was most thoroughly demonstrated. The many special functions of the radio personnel will also be described later, for it should be observed here that the diversity of employment was developed to a point which it is probable that few officers of the Army before the war had thought of, much less provided for.

Brigadier General Edgar Russel, Chief Signal Officer, American Expeditionary Forces, who arrived in France in June, 1917, had seen long service and distinguished himself as an officer in the Signal Corps, having served in Mexico and the Philippine Islands. He was well aware of the inadequacy of our Army's radio personnel and equipment and realized that it would not be easy to overcome the deficiencies. The problem of personnel was similar to that of all other branches of the service. Men could be given their initial and fundamental training in the United States contemporaneously with the training of the other services. But equipment in enormous quantities and especially constructed for war uses had to be provided from the beginning, and radio equipment of this character was not available in the United States. There were experienced American manufacturers to be called upon, but their capacity was limited and the large requirements of the Navy demanded added output. It soon became evident to General Russel that his supply must come from one of our Allies. Soon after his arrival he arranged with the French authorities to obtain from them the necessary radio and T. P. S. (ground telegraph) equipment for our troops until such time as these could be supplied from the United States. His foresight in this direction will be further emphasized in the story of supply.

The French Army made greater use of undamped wave sets than any of the armies. The probable reasons for this may be of interest. Prior to the war it was a well-known fact commercially that the German spark sets were superior to the French spark sets. At the beginning of the war, so French officers told us, the German Army's

radio equipment and communication was considerably superior. The French, realizing the necessity for better equipment, wisely appreciated the possibilities of vacuum tubes for transmitting and receiving; then decided, therefore, that the use of spark sets would be restricted to those types suitable for front line work, where simplicity is the controlling factor. For all other wireless communication they adopted undamped wave sets which used the same type of three-element tube for both transmitting and receiving, thus greatly simplifying their supply problem.



The very old and the ultra-modern joined hands in wartime when a divisional wireless station was installed by American men of the Signal Corps in this ancient chateau, erected about 500 A. D.

Now as to the importance of wireless. Radio telegraphy, it must be remembered, is essentially the emergency communication method of the Army. In trench warfare where positions were permanent and troops did not change their lines—in some cases for years—wire communication was preferred and desired: very complicated wire systems were installed and maintained even under conditions of greatest difficulty. But even in these positions, radio stations were provided to take up the burden of maintaining communication in time of heavy shelling, when the wires were broken and could not be repaired. In mobile warfare, on the other hand, radio immediately demonstrated its superiority over all other means of communication and those officers best qualified to judge are convinced of its even greater utilization in future wars.

Radio operations take on the general character of the other activities of an army in that, in a general way, they can be divided into offensive and defensive classes. The use of this classification in regard to communication may seem strange, but it can be easily explained. Offensive radio may be considered as its use in establishing and maintaining communication during battles or other operations in the same manner as the telephone and telegraph or visual signals are used. The superiority of radio at such times is at once evident, for any method of communication requiring wires is too difficult to erect and is entirely too vulnerable to injury in the deluge of artillery projectiles hurled in modern battles.

The one fault in wireless communication which has not been practically overcome to date, although the problem is now under consideration in many laboratories, is that it cannot easily be made a selective or secret means of communication. The fact that all radio work can be heard by the enemy brings us to the so-called defensive radio. If the enemy can overhear your radio stations, he is equally handicapped by the fact that you can hear his, and therein lies your opportunity to profit by the old adage that "forewarned is forearmed."

In the mobile warfare that brought us the victory, ground telegraphy proved to be practically worthless and will probably be displaced in future wars by small wireless sets using loop antennae.

Wireless equipment for tanks was one of the problems that long defied solution. A set was finally developed that makes possible communication with the post of command and co-operating airplanes.

As might be expected, military communications are never transmitted in plain language. Code is always used. Cipher has been discarded because it requires too much time to encipher a message for transmission and because it can be accurately deciphered by mathematical methods.

Phrase code was used principally, and was frequently changed. In spite of all precautions, however, one of the main sources, if not the main source, of intelligence regarding the enemy's projected operations lay in the interception of messages by the Radio Section (Intelligence) of the Signal Corps. These Radio Sections (Intelligence) were the defensive radio organizations of the army. Whereas each combat division numbered among its troops a Field Signal Battalion included in which was one company of 75 men, assisted by certain men of the outpost company and some from the infantry signaling detachment, which was expected to maintain the radio communication within the division, the Radio (Intelligence) Section was not attached to any unit smaller than an Army and was expected to cover our entire front and operate wherever needed. In addition to the duty of intercepting messages from ground and airplane radio stations of the enemy, these men were charged with the responsibility of locating them by direction finding or goniometric stations, noting the channels of communication and every characteristic that might tell us how many and what troops were opposing us, and their probable plans for our future destruction. How the plotting of the location of stations and channels of communication clearly indicated the enemy's organizations is a fascinating subject; the methods used will be explained in a future article, as well as the counter efforts of the enemy to confuse our radio intelligence operators.

Included in the duties of the Radio Section was the operation of the so-called Listening Stations. These stations were intended to intercept all messages from the enemy's T. P. S. (ground telegraph) stations and all grounded telephone or telegraph lines. Grounded lines were never intentionally used by any army in the latter part of the war, but no electric circuit could be maintained in a proper state of insulation and balance which would prevent our listening stations intercepting the

messages carried thereon if it was anywhere near us, as was the case during the position or trench warfare stage.

Low frequency amplifiers were connected to long leads running to grounds placed as near the enemy lines as possible. The stations were necessarily installed in dugouts within a few hundred feet of the front line trenches and the experiences of the men who were assigned to operate and maintain these stations were among the most heroic of the war. As the effectiveness of these stations depended upon the nearness of their grounds to the enemy's wire lines, our men when carrying these ground wires over into the enemy's territory, performed some of the most daring deeds of the war. One of the subsequent articles of this series will tell how these expeditions were carried out; how one of our men actually went over into the enemy's trenches and connected to important lines of telephone communication, enabling us to intercept Hun conversation for several days before it was discovered.

This ground telegraphy—developed by the French during the war and known to them as the T. P. S. (Telegraphie par Sol)—was made practically possible by the development of amplifiers utilizing three-electrode vacuum tubes. The transmitter consists essentially of a 50-watt induction coil, the primary circuit controlled by a telegraph sending key in series with the storage batteries carried as the source of power. The secondary of the

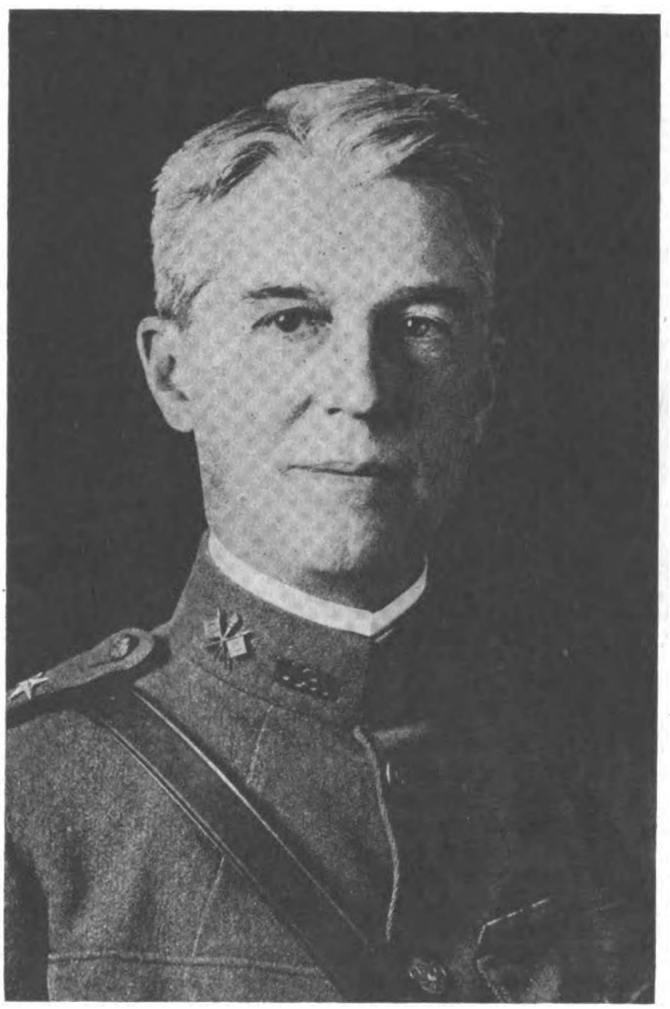
One of the main sources of intelligence regarding the enemy's projected operations lay in the interception of messages by the defensive radio organizations of the U. S. Army.

So-called listening stations were installed in dugouts within a few hundred feet of the front line trenches; the experiences of the men who were assigned to this duty were among the most heroic of the war.

induction coil is grounded through wires carried to grounds about 100 yards apart. Transmission is effected by the lines of flow of current between grounds which are intercepted by the receiving station. Audio frequency amplifiers, such as were used in the listening stations, were used for receiving, the receiving amplifier being also connected to ground plates separated by distances of 100 yards or more. It is a very crude means of communication, because of its efficiency being so dependent on local conditions; its use therefore, was necessarily limited, but in trench warfare of fixed positions it served very well in many places of favorable terrain.

In the mobile warfare that brought us the victory it proved to be practically worthless and ground telegraphy will probably be displaced in future wars by small but efficient portable radio sets using loop antennae. In open warfare T. P. S. stations soon lost track of their relative positions and consequently lost their communication when endeavoring to establish a station in a new position. One of the greatest defects in this means of communication was found in the necessity for the long ground leads which were difficult to maintain, and the requirement for ground circuits of the receiver to be in such relative position as to intercept a maximum of potential and current. The system was never reliable for more than 2,000 yards, and then only under the most favorable conditions. Where a river or other low resistance path for electricity intervened between the transmitting and receiving station the distance was reduced proportionately. But for several years T. P. S. was the main reliance of the French, and for a time of our own troops for front trench line emergency communication. In an attack at Seicheprey our troops in repelling the attack used this means of communication, whereas the Boche carried over with him a portable radio set of the spark type and also a telephone line which was extended with the advance. His reasons for carrying the radio seemed rational, and judging from the telephone circuit, he evidently expected to occupy the position permanently. The fact that both means of communication fell into our hands before the fight ended indicated a miscalculation on his part.

The enemy also used ground telegraphy in the front trenches which made the establishment of our listening stations essential, so that these could fulfill their intelligence-gathering function for this means of communication exactly as did the radio intercept stations in gathering the enemy's messages from the air.



Brigadier General Edgar Russel, Chief Signal Officer, A. E. F., who early in the war realized the inadequacy of our army's equipment of apparatus and personnel; his foresight contributed largely to the eventual success of the American signalmen

Ground telegraphy (T. P. S.) messages were coded of course, but no code or rules or regulations have ever been devised which will prevent indiscreet conversation over the telephone. German efficiency experts evidently failed to devise any means to prevent these leaks and German conversations were constantly overheard. This required that all of our men employed in listening stations should understand German readily, as well as have the ability to record telegraphic code. As a matter of fact ground telegraphy sending is necessarily slow; interception of the code was found to be much easier than the determination whether a faint gutteral voice from the enemy's line was demanding more ammunition or more men. At first we endeavored to get German-speaking radio operators, but

the supply was limited; so we selected men who understood the German language and taught them code at the same time when we were coaching them in the use of the equipment and the German military phrases they might expect to overhear.

Another, and possibly the most important function of these listening stations, was the so-called "policing" of our own telephone lines. We knew that alert German ears were also pressed to receivers of their listening stations and could overhear indiscreet language on our lines. Code names were provided for all places, units and common subjects of conversation over our lines, but in the press of action—and, sometimes, even in the quietest hours—our officers failed to realize the danger of using plain English and neglected to obey the orders and instructions forbidding its use. Our listening stations were constantly on the alert for these indiscretions and many a high rank-

A radio intelligence detachment was housed in this old barracks when the Boche became suspicious and put over a few shells; the soldier is standing in one of the resultant holes

ing officer was embarrassed by having a verbatim report of his careless words handed him a few minutes after he had completed a telephone conversation.

As has been stated, a perfectly balanced insulated metallic telephone circuit cannot be overheard, so that the condition of the line was also revealed by these stations and immediate steps would then be taken to repair the circuit in question.

We learned how the enemy appreciated the potentialities of our listening stations when our troops captured some German trenches in the latter part of the war. Their telephones were sealed up and captured orders indicated that these phones were only to be used in the greatest emergency; the officer breaking the seal was required by these orders to send in a written report as to the necessity for its use. In some parts of the line, as far back as two miles from the front, German telephones were found to be sealed up, indicating a respect for our listening stations exceeding our own, for we did not expect them to be over that distance.

All of the various fields of military radio activity so far outlined were practically a sealed book to the American Army before its entrance into the war and the gigantic undertaking of training and equipping the personnel for this work represents one of the greatest achievements of our army. Lt. Col. Krumm sailed for France in September, 1917, with as little real knowledge of the task before him as many of his readers. Samples of some of the French radio and T. P. S. equipment had been shown to different officers here under injunctions to observe the greatest secrecy, although many of them embodied no new ideas.

No real information of how the equipment was used or the scope of the work was forthcoming, especially in regard to the radio intelligence work. This phase of communication was always kept from general discussion in our own army, even after we had been in the war for a long time. It was considered that the less the enemy knew of our activities, the less preventative measures he would take against them. Few, if any, officers or soldiers who were not directly concerned in the intelligence work were aware of the fact that much of the information that guided their operations had been obtained by the Radio Section. The only other sources of information comparable with it were the prisoners captured from the enemy. By the same token, the less our men knew of our work the less they could tell should they fall into the hands of the Germans. If the location of a listening station became known its effectiveness was immediately destroyed by the counter measures taken against it, so that many a doughboy noted the strange equipment in a dugout in his sector without knowing its purpose.

The Germans are generally given credit for first discovering the possibilities of these ground listening stations and the precautions they took at the outset to keep the men assigned to this duty from coming in contact with other soldiers and discussing their work, are interesting. They were given extra pay, their meals were brought to them and they were pampered in every way and they were evidently the most exclusive branch of service in the German army. Once the work became known to the Allies, though, this exceptional treatment was discontinued and these "cellar detectives" were treated like the rest of their army.

In the early Spring of 1917, a French delegation headed by Dr. Abraham, the well known scientist was sent over to the United States to demonstrate the wireless and T. P. S. equipment used by the French Army, but the information was treated more as of scientific interest than as vital for general distribution among those who would later be called upon to use it in the field or to guide them in the manufacture of similar equipment in this country. Specimens of the apparatus in use by the French Army were furnished, which were to be used to guide the development and production in this country of equivalent material so that the U. S. Army could later be entirely independent of European supply. The fact that this desirable and, if the war had continued, possibly essential condition was not attained has already been told. The French Government had promised, meanwhile, to provide all the necessary radio equipment for the American troops until such time as production could commence in the United States, and this they were able to do until the drive of the Germans in March, 1918, when the rapid advance toward Paris resulted in a loss to the French of enormous reserve supplies of radio equipment. They were brought face to face with the urgent necessity of re-equiping their own men without considering ours. Added to that, it was these dark days of the war that brought on the influx of American troops at the rate of ten thousand a day—figures entirely beyond the calculations of the French when they agreed to furnish us the necessary radio equipment. Our own material had not been satisfactorily developed or produced in quantities in the United States and we were unable to look there for relief. Of those who watched the progress of the battles around Chateau Thierry, none were more harassed by anxiety than the officers who were concerned in the problem of obtaining radio equipment for our troops.

With the turning back of the Huns on their tracks toward Germany and the removal of the threat to Paris, where most of the radio factories of France are located, the French Army authorities regained confidence and the supply of wireless equipment was resumed. The British were never able to furnish us any amount of apparatus

and it was inadvisable to use different types, which would complicate the supply and maintenance of equipment as well as the training of the personnel.

Tours of duty with both the French and British Armies had indicated to Lt. Col. Krumm that the French equipment was equal to the British and more suited to the methods of the American Army, so that no concern was felt as long as it was possible for the French Army to provide us with radio material. Nor was there any doubt as to the ability of our men to handle the apparatus; the standard of operators of this country is as high as that of any of the Allies, and events proved our faith in our men to be well founded.

It might be well at this point to acknowledge the debt this country owes the amateur radio operator for the work he did in the Army. In his position as Chief Radio Inspector, Bureau of Navigation, before the war, Colonel Krumm had looked upon the amateur radio man somewhat as an omnipresent American evil, like mosquitos. But it was these amateurs who were among the first to respond as volunteers for the Signal Corps, and his respect for them increased immediately and it has never since abated. Subsequently, their excellent work in the field under the most discouraging circumstances, under the most trying and uncomfortable conditions, has earned them a place in history. Too generous appreciation cannot be recorded of those who fostered and cultivated this invaluable source of supply of American radio operators, probably without ever realizing just how well they had planted the seed. Allied officers often spoke of this phase of our personnel supply and regretted the interest in radio matters had never existed in amateurs of their countries, as it had in ours.

The value of real enthusiasm for his work—an outstanding characteristic of most amateurs—was particularly shown in the radio intercept stations. The ideal operator for this work is one who never for one instant ceased to hunt for enemy stations with his receiver. He must record a jumble of mixed letter groups which to him mean nothing. A mistake of one letter in a three letter group will probably throw the decoders entirely off the true meaning of the message. He must record the wave length used and get all the prefixes so that the stations

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When we entered the war the U. S. Army had in use only two types of wireless equipment; neither of these sets could be used in France.

Officers of the line did not take radio seriously. One whose unit had been isolated in the Argonne sent back this wireless message: "All communication cut off. How shall I keep in touch with you?"

The various fields of usefulness found for wireless were practically a sealed book to the American Army; the gigantic undertaking of training and equipping the personnel for this work represents one of the nation's greatest achievements.

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communicating can be determined. But above all he must instinctively note every personal characteristic of the senders "fist," or transmitting methods. Many a German organization has been traced all along the front by some peculiarity of a radio operator attached to it, who did not realize the necessity of absolute uniformity in sending. To detect these things the intercepting operator must never let down the intensity of his interest. The enthusiasm of the amateur for his work was one of his biggest assets.

Unfortunately for the Army, a very large proportion of the commercial and amateur operators joined the Navy at an early date, so that the supply of expert men available was soon exhausted, and the many additional men required had to be trained. This branch of our activities holds many points of interest and will be covered more fully at another time.

Officers of our Allies often indicated their belief that our men were notably successful because they were fresh in the work, but they expected when we had been in the war as long as they had, that we would also lose our enthusiasm and effectiveness. This no doubt was true to some extent, and it applied in a minor way to all branches of the service, but on the whole the American Army can look back on the work of its radio personnel with genuine and particular satisfaction.

When a man has had three or four years of operating under constant shell fire all the glamour of war disappears

This listening station in the Vosges is typical of those maintained so secretly by American wireless men that doughboys in the same sector never learned the purpose of the strange equipment

and the daily communication duty becomes a grind. This view was illustrated one day when Colonel Krumm visited one of the French artillery receiving stations to which range corrections from airplanes were wirelessed. As the visitor was regretting that his limited knowledge of French prevented him from questioning the operator, the latter in good English informed the American officer that he knew him in New York. The operator then explained that he was a New York boy of French parentage and had joined the French Army three years before, resigning his position as a Marconi operator on a ship sailing out of his home port. Commercial operating had never been like his present job, he readily admitted, and added that he was "fed up" with the war thing. This was in the Champagne country during the disheartening days of the Fall of 1917. Our men never experienced the depressing effect of the discouraging battles as did the Allied operators—so it is fair to assume that the Allied officers were right in their estimate of American effectiveness.

Captain Taylor joined the A. E. F. in December, 1917, about the same time as the first detachment of about seventy expert operators arrived. The Radio Section (Intelligence) of the Radio Division was then organized. The accompanying chart shows the scope of this organization and the duties of the Radio divisions on the day the armistice was signed. On December 8th, 1917, the first radio intelligence stations, intercept and gonio, were established in a French sector. It was considered advisable to operate some intelligence stations in the French position so our men, both operators and decoders, would have an opportunity to work under actual fighting conditions. The radio intercept and goniometric stations were there-

CHIEF SIGNAL OFFICER AMERICAN E. F.

RADIO DIVISION
Lieut. Col. L. R. Krumm
OFFICER IN CHARGE

CO-ORDINATION SECTION
Captain Willis H. Taylor, Jr.

Function:

Co-ordinates work of other sections as follows:

Maintains liaison with Division of Research and Inspection and Radio Div. at Washington.

Checks all requisitions to Supplies Division.

Supervises and co-ordinates radio requirements of Tank Corps, Artillery, Sound Ranging and other arms of service.

Supervises development of such equipment as radio tractors, trailers and other radio auxiliaries as necessity arises.

Formulates radio bulletins covering field instructions for the operation and maintenance of radio equipment and auxiliaries.

AIR SERVICE SECTION
Major F. N. Shumaker.

Function:

Installation and maintenance of radio equipment on airplanes.

Supervision of operations of independent squadrons.

Prepares originals and checks Air Service requisitions for radio equipment to be checked by Co-Ordination Section.

Indicates Air Service personnel needs to Correspondence and Personnel Section.

Maintains liaison with the Air Service and in general co-ordinates the work of that service and furnishes information as to the needs of the Air Service.

Prepares technical instructions for guidance Air Service Radio Personnel.

OPERATIONS, TECHNICAL SUPERVISION OF RADIO OPERATIONS IN THE FIELD

ASSISTANT CHIEF SIGNAL OFFICER

G. H. Q. Radio Section Signal Corps—3 officers and 75 men. Operation of long wave intercept stations at G. H. Q. Information collected for Radio Intelligence Sec. G. S. G-2.

TRAINING SECTION
Captain Harlowe Hardinge, Hq. 2nd A. I. C.

Function:

Supervises the training of the radio personnel of the army other than the Signal Corps for which the Signal Corps is required. This includes Air Service, Tank Corps and Artillery personnel.

The training of the Air Service personnel covers squadron radio officers, pilots, observers, radio mechanics and operators and the special personnel of the bombing squadrons involving direction-finding and navigating radio equipment.

All the above work is covered at several fields in France and England.

Training of the Tank Corps signalling personnel, the most important part of which is radio training. This is carried on at the main tank center.

Various officers are sent from this section to different artillery training areas as requested for the establishment of radio schools and the training of artillery radio personnel.

Indicates to the Cor. & Pers. Sec. the number and qualifications of the Air Service personnel which has completed training and which is available for assignment to active duty.

Submits necessary requisitions for equipment and Air Service facilities to accomplish the above training.

CORRESPONDENCE AND PERSONNEL SECTION
Lieut. Ray Rice

Function:

Compiles monthly, weekly and other reports.

Supervises office, personnel correspondence and files.

Radio Division, Signal Corps and Air Service personnel, records and matters.

Requests necessary orders covering movements of Signal Corps and Air Service radio personnel and maintains the necessary records covering personnel.

OFFICER IN CHARGE, RADIO SECTION BASE
Major Robert Loghry

Function:

The work of this Base is accomplished by utilizing the authorized organization of the Army Radio Section with such extra personnel attached thereto as is necessary. These duties include the operation of the intelligence system of the different armies as required by assigning radio detachments to each army under the command of necessary officers.

The assignment of call letters and wave lengths to the different armies.

Technical co-ordination of the radio operations of the different armies.

Maintenance of a store room where radio equipment is overhauled and repaired.

Submits all reports, technical request and requisitions to the Chief Signal officer through the A. C. S. O., G. H. Q.

Supervision and co-ordination of the radio work of the independent Air Service force.

Trains replacement personnel for the radio detachments, maintenance of a school and operation of practice stations.

Has available field instructors capable of teaching troops the use of radio and T. P. S. equipment.

Supervision of field tests of radio equipment under development.

CHIEF SIGNAL OFFICER OF AN ARMY

RADIO SECTION DETACHMENT
Function:

Operation of the radio intelligence stations of an army consisting of control, intercept, gonio and listening stations.

Supervisory work of the radio activities in the army as desired by the Chief Signal Officer of each army.

CHIEF SIGNAL OFFICER OF AN ARMY

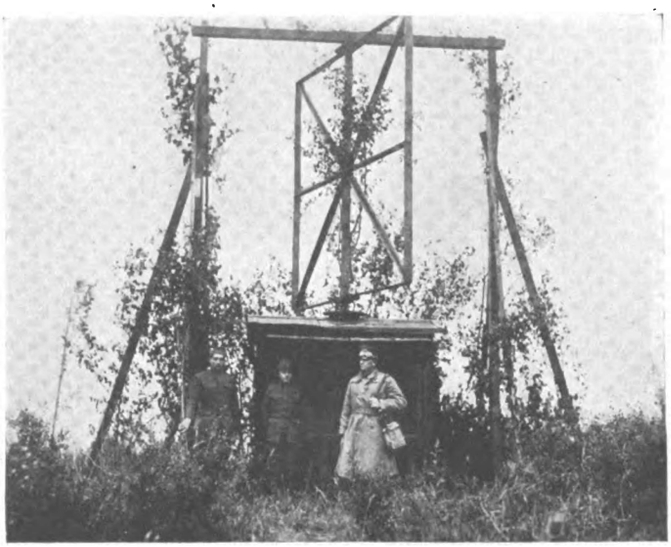
RADIO SECTION DETACHMENT
Function:

Operation of the radio intelligence stations of an army consisting of control, intercept, gonio and listening stations.

Supervisory work of the radio activities in the army as desired by the Chief Signal Officer of each army.

fore established to the west of Verdun in territory held by the French and covered by their own radio intelligence system. Our stations were understood to be practice installations and every assistance was given us by the French to become acquainted with the practical phases of the work. Thus we were pleased and flattered when, within a short time, we received a request from them to furnish copies of all the messages and goniometric readings recorded; subsequently we had reason to know that they were exceedingly grateful for our assistance.

With the entrance of our troops into the line came the real test of our radio communication. The training or practice which we carried on under conditions which appeared to be exactly those of actual warfare seemed advantageous; but how fallacious this idea was quickly developed in the operations. The first troops to go into the line had been given several months' training; the



A camouflaged gonio, or wireless compass station of a type operated by the Radio Section (Intelligence) Signal Corps, in France

officers had been afforded an opportunity to visit sectors held by the French and English troops and had been in the atmosphere of war for several months before actually participating in it. Later, when our soldiers were arriving at the rate of two divisions a week and were sent into action almost immediately, many of the signaling troops were unfamiliar with the radio equipment and had only a sketchy knowledge of their proper function in the communication system. Troops which went into the line with the British Army, after training with French sets, were provided with British radio equipments. Because of the delay in producing equipment in the United States few of the radio personnel sent over to the A. E. F. were properly trained or prepared to take up their work, in fact, their first knowledge of duties and the equipment which they would use was gained after their arrival in France. This made radio training one of the hardest problems. Yet in spite of the many handicaps nearly all acquitted themselves with credit and the difficulties overcome by the different radio companies of the Signal Corps will make interesting reading.

Considering the short period of training given our signalmen the results were magnificent; possibly the principal factor in restricting the usefulness of our radio was the ignorance of many American officers as to its limitations and possibilities. The reluctance of our officers to code message was the greatest single handicap. Operators were absolutely forbidden to transmit anything "in the clear" and all messages were required to be handed them in code. So difficult was the enforcing of this requirement that the probable future practice in handling these messages will be to have them coded by the Signal Corps personnel. The failure by line officers to take radio seriously is illustrated by an episode. said to have occurred in the Argonne. An officer commanding a unit which had become isolated sent back the following radio message: "All communication cut off. How shall I keep in touch with you."

Earlier in the article one class of radio operations was referred to as embracing offensive activities, to indicate the use of the wireless telephone and telegraph as a means of communication between the different units and branches of service of an army. This not only includes stations at different infantry battalion and regimental headquarters, brigade, division, corps and army headquarters, and similar units, but also the special radio services of the air service, the tank corps, artillery sound ranging by the engineer corps, and the meteorological service. All have highly specialized requirements, especially the air service.

At the beginning of the war the air service was part of the Signal Corps, which is the communication branch of the army. At that time the wireless communications of the air service were supervised by its own radio division as part of the Signal Corps. Later, when the air service was separated from the Signal Corps and established as a separate service, its radio organization was continued. It was found advisable, however, to centralize the supervision of the radio of the air service in the Signal Corps, and about a month before the signing of the armistice this work was taken over by the radio division of the Signal Corps, so that all radio operations of the army properly came under the supervision of the Chief Signal Officer, A. E. F. Radio equipment for the airplanes engaged in war operations must be governed by the peculiar requirements and limitations of the flying craft, but the major portion of their work is with ground stations. Radio communications between planes in flight and from the ground to the planes was never reliably accomplished, in fact, in the war operations of the air service in France. Radio telephonic communication between airplanes—the goal of the air service of every army and the essential requirement if squadrons or larger bodies of planes are to act as a unit—is a subject which was given preferred attention in the United States. Various articles have been written indicating results achieved in the development of radio equipment for communication between and to airplanes from the ground. The sets developed in this country were received shortly before the armistice; they were being tested out and personnel was being trained when hostilities ended. But the radio telephone was never used by our air service in actual combat.

In the so-called artillery reglage work where the airplane observer supplies batteries and groups of artillery with information indicating the accuracy of their shell fire and the correction necessary to obtain the greatest results, our airplanes were probably as effective as those of any other nation. In this wireless work they used the French spark sets, a very simple and light equipment, utilizing a wind-driven generator mounted on the fuselage with the rotary gap on the generator shaft. A trailing single wire antenna was used.

Airplanes were also used for reconnaissance, supplying information by radio to unit commanders regarding the activities of the enemy, and also in many cases the position of our own line. It must be remembered that in mobile warfare, calling for rapid advances such as marked the last part of the war, many of the units were located in woods or other positions which the commanders themselves were unable to recognize. Airplanes thus became the most accurate source of information as to the location of the advancing lines.

Tank radio was also one of the most interesting and difficult questions which confronted American research experts. No wireless equipment had been devised which

would operate from a moving tank. In the British Army the tanks merely acted as transports for the set; it was the practice to drop the set from the signaling tank, establishing it in some protected and suitable place as near the front as possible. The French had experimented with a set using a trailing antenna, but it was found to be unsatisfactory and as far as known never was used in action.

A large antenna cannot be used on a moving tank; it must be small, easily erected and removed. An undamped wave tank set was developed in the A. E. F., so constructed that the radiated wave length was entirely independent of any change in the antenna, which was of the umbrella type consisting of a short pole projecting a few feet above the tank with ribs that could be spread as desired. A sample equipment had been sent back to the United States before the armistice, but had not been put in production and supplied us in time for use. The possibilities of this set cannot be over-estimated, as the mobility of the tanks makes a reliable means of communication absolutely necessary; with an efficient wireless installation they could not only have communicated with their post of command, but with the airplanes working in conjunction with them.

Artillery receiving stations work with reglage airplanes controlling their batteries. Sound-ranging receiving stations were provided to note the radio activities of enemy airplanes, the prelude to their artillery activities. The wireless method was also used in communicating meteorological data, of the utmost importance in the regulation of artillery fire and airplane operations. Weather and meteorological information was sent out approximately every four hours. Spark equipment using approximately the same wave length and spark characteristics as the airplane stations were used for this purpose.

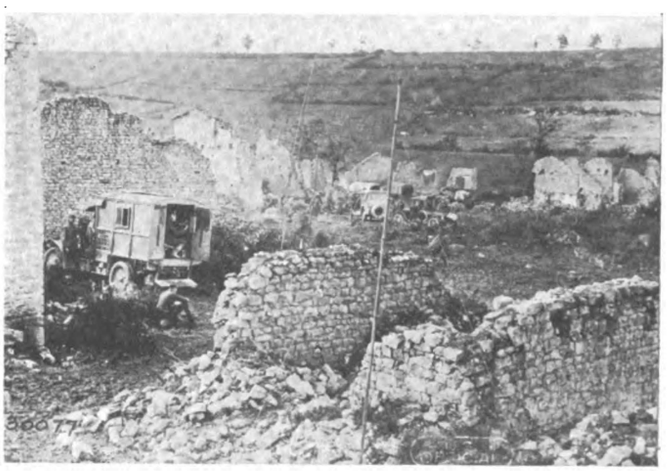
The personnel necessary for all these special radio activities required highly specialized training and this was accomplished as well as time and facilities allowed at many points in France and England. A large school was established at the Air Service training center at Tours, where observation officers were trained in the use of their radio equipment and radio operators and mechanics were developed in large numbers. Captain Harlowe Hardinge, a trained engineer, who had been one of New York's most enthusiastic amateurs before the war, was in charge of the radio school at Tours and the excellent results attained there are largely due to his ability. Other training centers were established for instruction in artillery fire control by wireless, tank radio, and in England a school was to be conducted for the instruction of personnel for the operation of direction-finding equipment, wireless apparatus which enables bombing planes to attain their objective at night and return to their home field.

The debt this country owes to the amateur radio operator in the Army is acknowledged in this article.

These civilians were the first to respond as volunteers and their excellent work in the field under the most discouraging circumstances has earned them a place in history.

Allied officers often spoke of this source of personnel supply and regretted the lack of interest in amateur work in their countries.

The supply of radio apparatus had its special problems. This was an undertaking which necessitated the most careful compilation of advance requirements, so that the ever increasing and overwhelming numbers of American troops might be promptly supplied with the proper radio equipment which would enable them to take their place in the line without delay. To this end all of the production facilities of the French operated in conjunction with the excellent general supply system of the Signal Corps. It should be appreciated that the French were practically unprepared to manufacture radio equipment in quantities sufficient to meet the needs of the French Army, yet the problem was enormously complicated by the wholly unexpected arrival of an immense American Army in an incredibly short period. Considerable readjustment of their manufacturing plans was required to meet this demand. General Ferrie, Chief of the French Military Radio Telegraphic Service, and his staff will always be remembered in this connection for their untiring efforts and co-operation in this difficult task.



Divisional Fiat tractor radio station in operation within ruins to avoid detection

While it was the policy of the Signal Corps not to manufacture any radio telegraphic or telephonic apparatus in France, the equipment purchased had to undergo rigid inspection before acceptance from the French Government. This work required men familiar with all phases of manufacture. Well equipped laboratories were established to provide for this important function, and to conduct the research work necessary in the development and solution of immediate problems. Here, too, was centralized that necessary research which served as the basis of intelligent constructive suggestions forwarded to the United States. In this work the Signal Corps was extremely fortunate to have Major E. H. Armstrong as an advisor on all technical matters. To him may be credited many achievements in connection with the constantly arising difficulties with apparatus and its maintenance, to say nothing of the radio development carried on by him in his laboratory.

The reader has now been given an outline of the great field of endeavor covered by radio men in the A. E. F. That these various activities required specialized methods and equipment is evident to laymen as well as those actively engaged in the art. The succeeding articles of this series will cover each subject in more detail, describe some of the French apparatus used and record some of the many experiences that befell our radio men in the A. E. F. while accomplishing results which should ever remain a source of pride to the whole American people.

(To be continued.)

October, 1919

The WIRELESS Age

Volume 7

Dancing to Music Wirelessed from an Airplane

Wireless in the A. E. F.

By Lieut. Col. L. R. Krumm and Capt. Willis H. Taylor, JD.

Wireless in the A. E. F.

First Authentic Account of the Organization of the Radio Division of the Signal Corps and an Inside View of the Great Obstacles which Americans Had to Overcome

By Lieut. Col. L. R. Krumm
Officer in Charge Radio Division, Signal Corps, American Expeditionary Force
and Capt. Willis H. Taylor, Jr.
Co-ordination Officer, Radio Division, Signal Corps, A. E. F.

Part II

"OUR telephone lines were cut beyond repair by shell fire; radio was relied upon to maintain the necessary liaison."

Such was the tribute paid to wireless communication in many of the reports of major and minor engagements of American troops which were submitted to the Chief Signal Officer of the American Expeditionary Forces. It emphasizes the importance of radio work.

The goal, at which all efforts were aimed, was to make radio communication a reliable means for maintaining liaison during emergencies in battle. Types and kinds of equipment to be used were the first consideration. Close upon this, in order of importance, was organization of the operating personnel and the formulation of instructions for operation of the equipment, comprehending such details as call letters, wave-length assignments and traffic regulations. These details were of the greatest order of importance in carrying on radio communication efficiently and with the least possible interference.

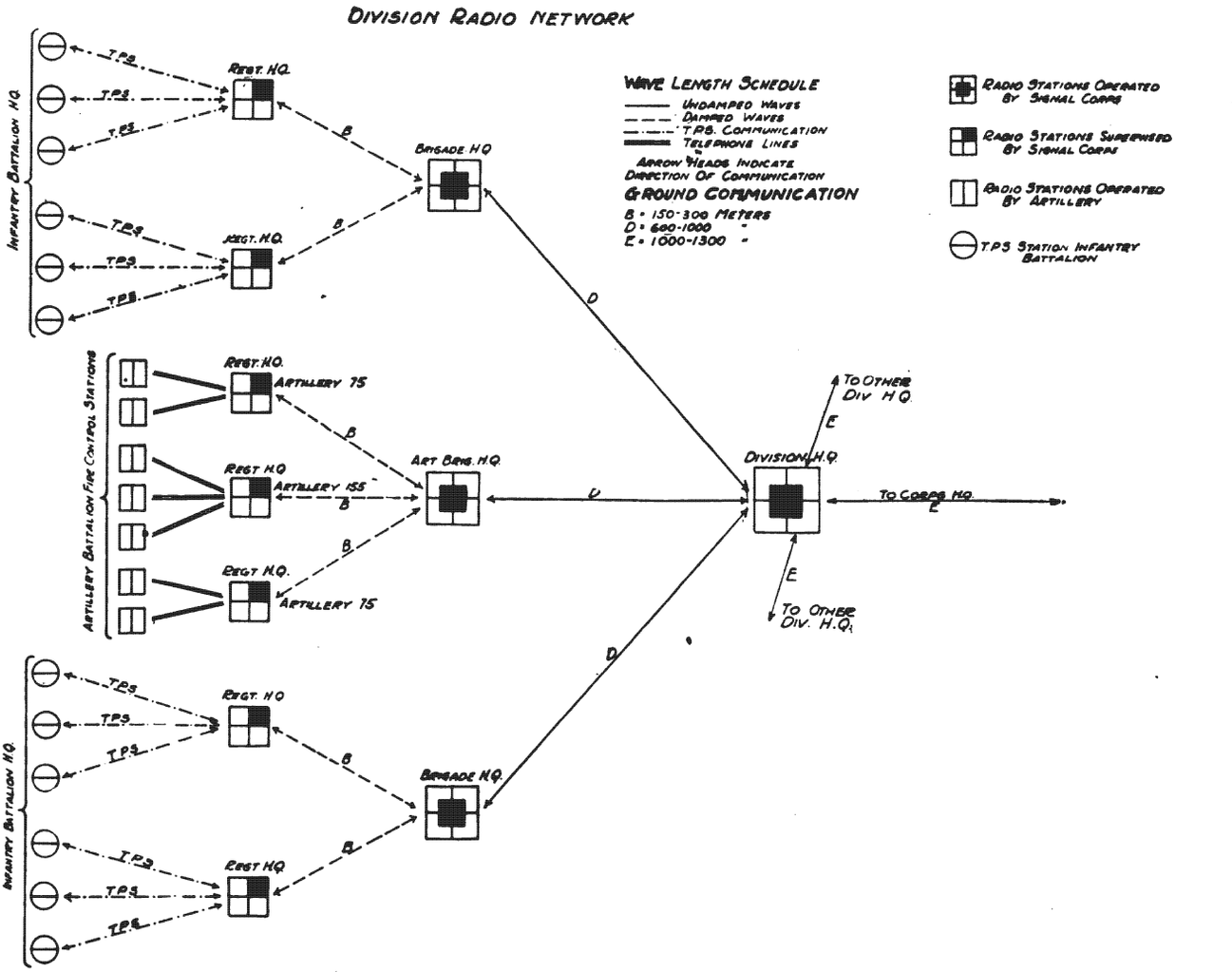
A Ford Tractor equipped with the Divisional Headquarters Radio Set Type E-3 or Type E-3 bis.

In a previous article it was pointed out that French apparatus had been adopted as the standard radio equipment for all American units, pending the development and production of equivalent material in the United States. This French equipment proved satisfactory in most respects, although the material used by the first of our troops left much to be desired, but as the war progressed and the later types of vacuum tube undamped wave sets came into more general use in our army the radio service became increasingly more satisfactory. These later sets reflected the long experience of the French army with radio communication, and also divulged the fact that the French engineers were considerably more conversant with the possibilities of the vacuum tube than we anticipated. In the circuits presented with this article the same tube was utilized for both transmitting and receiving. An innovation that immediately attracted the American signal officer's eye was the high frequency amplifier circuits developed and used by the French. At the time of our entry into the war, high frequency amplifiers had not passed the laboratory stage in the United States. In France they were being extensively used in the field, and with complete success. It is interesting to note that the British army took up the development of this type of amplifier with wonderful success and reports were current of a 19-stage amplifier in use by a land station in England which copied the bridge buzzer sets of the German fleet at anchor in the Kiel Canal — the Huns being so confident of their security from a wireless standpoint that they transmitted in plain German, much to the edification of the British Admiralty.

However, at the beginning, great was the scorn of the American operator—who had probably been a progressive amateur at home—when he was assigned to operate a spark set working on a plain antenna circuit. This type of equipment was used throughout a division at the beginning of our activities. In the trenches they were operated with an antenna elevated only about four feet above the ground, as shown in the illustrations, and were not very effective when so used. Higher antennae were possible at brigade and division headquarters, however, and here they were surprisingly effective, considering the amount of interference that naturally resulted from this type of equipment. Immediately, the American propensity to experiment became evident and it was indeed an exception to find a station in which the operator had not constructed loading coils to enable him to receive communications from Eiffel Tower on 2,500 meters, although his receiver was only intended for a maximum wave-length of 550 meters. Many a case of complaint against a station for not replying to a call was gravely answered by the commanding officer with the statement that the fault could not be with his station as he had about that time received a copy

of the French communique from his operator, showing that he and his set were effectively operating. The fact that the station was 2,000 meters off the wave-length of his net meant nothing in the busy life of a non-technical officer.

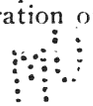
It must be kept in mind that under no other condition do the best laid plans of men go so much agee as in warfare, so in contemplating the carefully outlined plans shown hereafter, it must be kept in mind that radio, like all other branches of the army, was usually greatly disarranged from the operating plan. Under these circumstances it is obvious that the best



radio man in wartime is one who can meet conditions as they arise and maintain communication in spite of all contingencies; and it must be said that the resourceful man was nowhere more in evidence than in the radio work of the army.

The French radio authorities, like ourselves, had the impression that vacuum tube sets were too complicated and frail for use except at considerable distances back of the line, and only the simplest spark sets were in use when our troops first went into the lines. Later, undamped wave sets were put in use down to and including brigade headquarters, and in the Argonne many of these sets were with the front line troops accompanying brigade commanders who wanted their headquarters up with the very foremost.

The supply of the necessary storage batteries was perhaps the most difficult question which arose in the operation of our radio stations. The hand generator



which was used to a very limited extent. At first thought it might seem that the use of storage batteries as the primary source of power for wireless sets was entirely impractical, and so it first appeared to us. But their extensive use and the resultant type of radio equipment were entirely due to several years of trench or stationary warfare, a condition which affected our Allies' perspective. After their use was thoroughly established and the moving warfare stage developed it was then too late to change; a system of supply was developed in emergency, however, that was effective far beyond what would seem possible. The Germans used storage batteries, but they had also developed and were using many spark sets in which the power was provided by a gasoline engine and generator.

The details of organization of the radio operating personnel and the actual operation of the radio equipment in the various networks were so inter-related that no attempt will be made to discuss each one sep-

arately. Instead, an outline of the scheme of radio networks and wave-length schedules is given, through which one can arrive at a fair understanding of the details of the organization.

In the beginning—that is the beginning for the Americans—everything seemed simple enough. We had but few divisional artillery regiments equipped,

Interior of a Ford Radio Tractor for Divisional Headquarters showing the Radio Set Type E-3 bis mounted therein

practically no combat or observation airplanes, no anti-aircraft batteries or sectors, no railway or other heavy artillery, and no tanks. Our wave-length schedule and transmission systems were not complicated by innumerable networks and the radio communication system was briefly as follows:

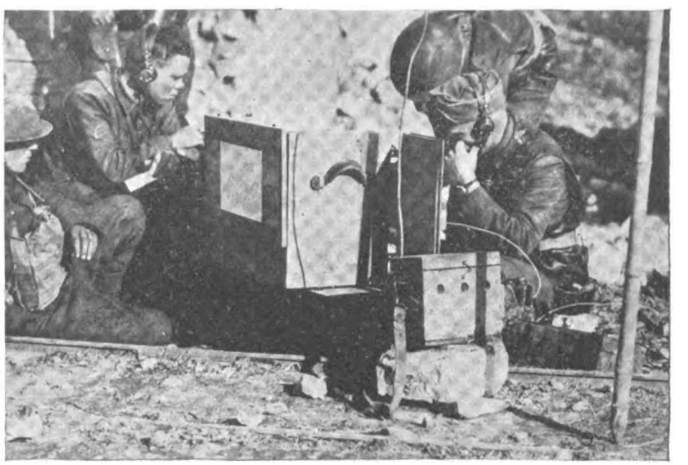
Ground telegraphy (T. P. S.) was provided for communication between regimental headquarters and battalion headquarters. The induction coil, plain antenna set, which will be described, was provided forward of divisional headquarters and down to regimental headquarters; undamped or continuous wave transmission was used between adjoining divisional headquarters and from divisional headquarters to army corps headquarters. At this time the army as a unit had not been organized; for that matter, army corps were novelties even in the early summer of 1918.

The divisional artillery was expected to have its shell fire controlled by radio from French observation and fire control airplanes, but it was sometime before satisfactory operations of this kind were obtained; more success was attained when American airplanes and operators worked with our artillery.

The wave-length assignments called for the allotment of 150 to 300 meters to regimental and brigade headquarters. This small wave-length range of 150 meters, together with the transmitting set, portable type, No. 4 (the small, plain antenna set already referred to) was the bane of many an otherwise religious sergeant's existence. The only way to change or adjust the wave-length was to change the height or the length of the antenna. A chart was actually compiled and distributed to some units showing what wave lengths would be obtained when an antenna of a given length was stretched between the 4-foot supports—providing, of course, that you had not lost the supports. Consider that divisional headquarters had to communicate with its three component brigade headquarters, two infantry brigade and one artillery brigade headquarters; also consider that each infantry brigade had two regimental headquarters and that the artillery brigade had three regimental headquarters. To this day it appears nothing short of miraculous that any reasonable continuity of communication was established through the interference. But it is a fact that, while the brigade and regimental interference was bad, divisional, brigade and regimental messages were successfully transmitted and received.

The undamped wave radio transmission between divisional headquarters and between divisional and army corps headquarters worked well from the beginning. The wave-length range assigned for this continuous wave communication was 600-1000 meters, giving a working range of 400 meters for this important radio service.

The equipment used for this service and wave-length assignment was a transmitting and receiving set known as Radio Set Type E-3. It was mounted on a Ford truck as shown in the photographs accompanying this article. These Ford trucks were originally ambulances, but were the only suitable vehicles available at the time we entered the war. One truck carried the radio equipment and a second one the charging set, extra storage batteries, charging switchboard and cooling tank for the water-cooled gasoline engines. The little flivver never essayed to perform a harder task and while many of them were in service until the last it was soon found that the car was too light for the work and a heavier truck of the Fiat make was utilized as they became available. All these trucks were rebuilt and equipped in France and were

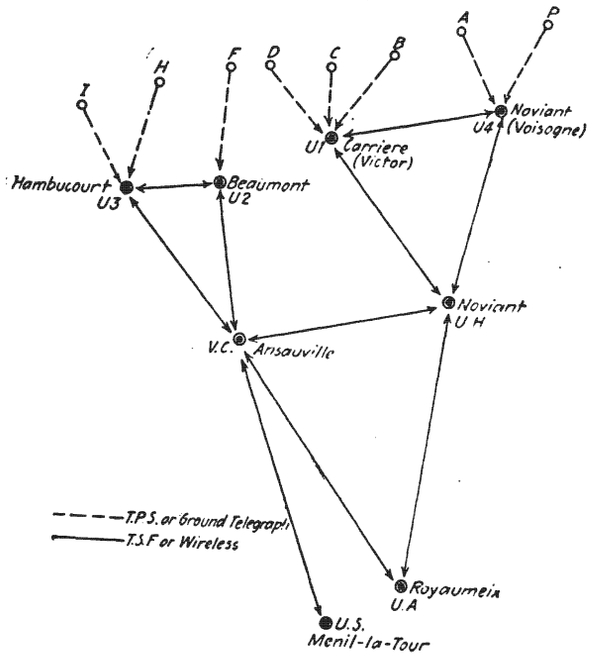


The real thing—A Brigade Headquarters radio station in action. This clearly illustrated the need of a light trailer to transport the E-10 bis set

so satisfactory that recommendations were made that all sets, even those with brigades, be mounted in light trailers. In the Argonne the trucks could not keep up with the troops in many cases because of lack of roads or other causes and the apparatus was dismounted by the operators and carried by hand. When it is remembered that it was vacuum tube equipment with its storage batteries, weighing from 200 to 300 lbs. some idea can be had of what this meant.

The system of radio liaison as outlined above was successfully employed by the 1st Division, when it took over the first sector held exclusively by a United States Army unit. This sector was in the St. Mihiel

or Toul sector and the divisional headquarters were located at Menil-la-Tour, while Rambucourt, Beaumont and Ansanville will be remembered by many A. E. F. veterans as regimental and brigade headquarters since many divisions received their first baptism of fire in this sector. The accompanying radio liaison diagram shows the scheme of communication using T. P. S. and radio by the 1st Division in this sector.



The first radio liaison plan of the A. E. F. (that of the 1st Division) when first occupying the Toul sector

During this embryo stage of the American army's radio activity the details for the future complicated schemes of radio liaison were being worked out. The successful operation of the E-3 type undamped wave tube sets, described later, had indicated to the French the advisability of a more general use of undamped waves. They developed the E-10 types which were simpler and more compact sets than the portable and sturdy E-3 sets, but considerably less powerful. This set was a distinct achievement on the part of the French radio engineers and was the keystone to the network schemes in use at the end of the war. In these networks the ground radio liaison, 100-150 meters wavelength was allotted to trench radio and a two-way tuned, damped wave loop set was contemplated to provide and maintain trench, company headquarters, battalion headquarters and regimental headquarters communication. This loop set was to be strictly an American apparatus inasmuch as none of the Allies had a corresponding set. The only loop sets were used by the British, but they were not entirely satisfactory and were only one-way sets. A two-way loop set designed by Maior E. H. Armstrong and Lieutenant Wm. H. Priess was actually constructed and successfully operated in the A. E. F. during tests before the date of the armistice. This set will be described later.

The range of 150-300 meters was allotted to regimental headquarters to communicate with adjoining regiments and with brigade headquarters. A tuned combined receiving and transmitting set was to be provided for this radio communication to take the place of the plain antenna set previously used, but due to the signing of the armistice the old French transmitting set, portable type No. 4 and the receiving set type A-1, were never replaced.

As a new departure the scope of undamped or continuous wave radio communication was extended to include brigade headquarters and the wave-length range of 600-1000 meters was allotted for brigade to division and brigade to adjoining brigade radio communication. This same wave-length range, 600-1000, was also used by Tanks to communicate with brigade or divisional commands. The set used for this service was known as Radio set E-10 bis, and was a portable transmitting and receiving set utilizing the same type vacuum tubes for both transmission and reception.

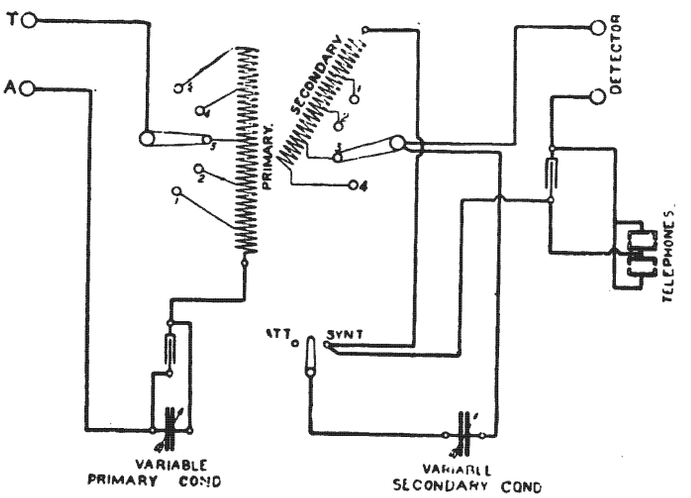
The radio liaison between division and army corps was allotted a wave-length range of 1000-1350 meters. This wave-length range was allotted to maintain radio liaison between a division and its adjoining divisions, between army corps headquarters and the army corps artillery headquarters, between army corps headquarters and the army corps air service headquarters, and between army air service headquarters and army corps air service headquarters.

The airplanes for observation and artillery fire control were allotted wave-length ranges as follows:

100-300 meters to airplanes communicating with and directing the fire of the divisional artillery. The same airplanes when operating as infantry contact airplanes communicated by radio to regimental or brigade posts of command on the same range, 100-300 meters. The set used for this service was a French wind driven generator spark set and was known as the transmitting set airplane type Y.

The wave-length range of 300-500 meters was allotted to airplanes communicating with and directing the fire of the army corps artillery and army artillery. The type Y airplane set was also used for this radio service.

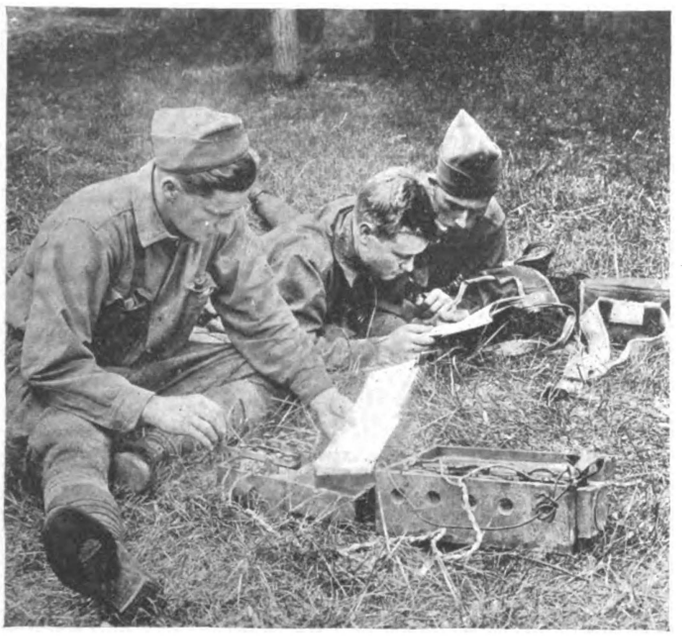
The wave-length range of 550-750 meters was allotted to airplanes for directing and controlling the fire of long-range railway and similar artillery and radio communication was maintained by undamped or continuous wave sets for two-way communication. The airplane set was known as the E-10 airplane set and the ground apparatus was known as the E-10 artillery set. Unfortunately the transmission range of the ground set was insufficient and the airplane set was not powerful enough for consistently successful use.



Circuit Diagram Receiver of Radio Sets Type E-3 and E-3 bis

After the wave-length range assignments were made, an organization was required to enforce them. This necessitated a compilation of rules and regulations for the operation of the various stations and also a systematized organization of the radio services. The proper organization of an Army suggests that the radio stations of each unit be controlled and oper-

ated separately. This can be done by having the stations of a regiment grouped and operated on one wave-length under control by the station at regimental headquarters. A divisional net would consist of the station at the division headquarters controlling the stations at the three brigade headquarters of that division, all of them working on the same wave-length. Adjoining nets were assigned different wave-lengths to reduce interference. It will be noted, however, that most stations required two sets, as they really are in



Practice Transmitting with Transmitting Set T. P. S. No. 2 bis

two nets, the lower unit which they command and the higher network to which they belong.

Each of the stations in a net was identified by means of a call composed of a letter and a figure; a letter and two figures; two letters. In certain nets these calls were changed daily according to the proposed plans. In each radio network or "net," the station which belonged to the highest military command unit was called the P. C. T. or Master Station. All of the other stations in the net were known as secondary stations and were under direct orders of the P.C.T., which controlled the traffic within the net when the net was working under control. The nets were named after the highest command to which they pertained and were: the Army Net, the Corps Net, the Division Net, the Advance Net and the Air Service Net.

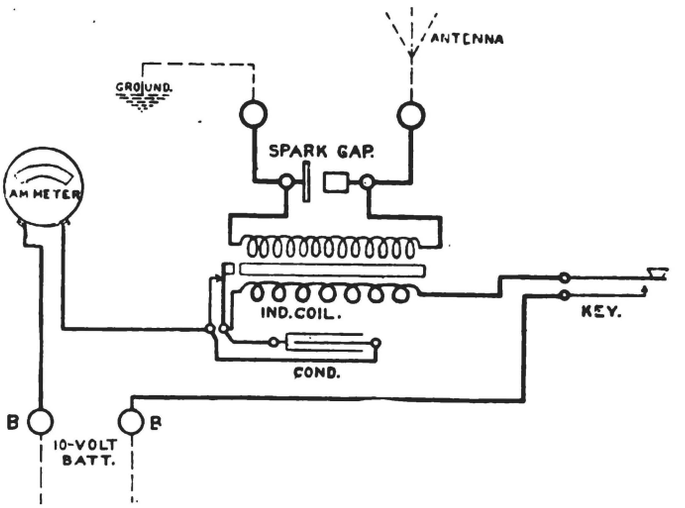
The Army Net included the stations at Army headquarters and the stations at the headquarters of each Army Corps, Army Artillery headquarters and Army Air Service headquarters. The Corps Net included the stations at Army Corps headquarters, the stations at the headquarters of the Divisions comprising the Army Corps and the Army Corps Air Service Group. The Division Net included the Divisional headquarters station and the stations at the headquarters of the Brigades of that Division, the Advance Center of Information and the Artillery Brigade headquarters of the Division. The Advanced Net included the Brigade headquarters station and the Regimental headquarters comprising the Brigade.

The exact wave-length, selected from the allotted wave-length range, to be used during operation in each net was fixed by the Radio Officer of the Army in which the net operated. This regulation of net operation was effected by means of radio liaison plans which were issued from time to time. When a net was operating, all of the stations in the net were listening. This necessitated that each station be sharply tuned to the prescribed wave-length and that the operator of each station have his head phones on and be following the traffic in the net. At no time was any station without an operator on duty, after the station had once reported into the net.

A net was operated either as a "free net" or as a "controlled net." When operating as a "free net" the P. C. T. or control station never interfered, but listened in to see that the secondary stations observed the operating rules. A station having a message to send called the addressed station after having previously listened in to guard against interference. In case there was disorder in the net the P. C. T. usually assumed control of the net by sending the conventional R. D. followed by the P. C. T. call, making it necessary for a secondary station to obtain permission from the P. C. T. before calling another station in the net. The P. C. T. sent the signal R. L. when the net was released from control and the net then became free.

The Network Charts and Wave-length Schedule accompanying this article will give some idea of the complexity of the network systems and the plans for the employment of radio-telegraphy will show what an undertaking it was to assign wave-lengths and call letters to all of the stations in the various networks, if interference was to be reduced to a minimum.

The assignment of equipment to stations can be noted on the network chart. It is described in detail



Circuit diagram of Transmitting Set Portable Type No. 4

and illustrated by the accompanying photographs and circuit diagrams.

The list of standard French radio equipment was as follows:

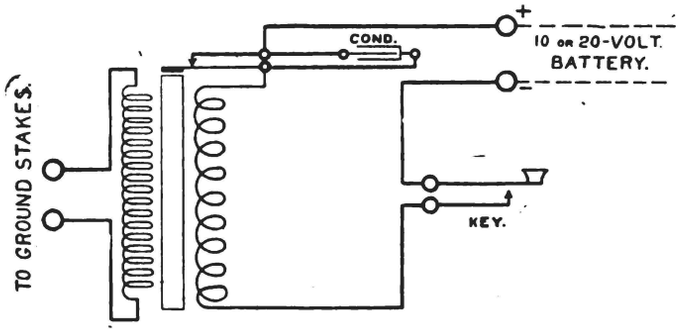
Ground Telegraphy
- Transmitting Set T. P. S. No. 2 bis
- Receiving Set T. P. S.

Radio Telegraphy
- Transmitting Set Portable Type No. 4
- Receiving Set Artillery Type A-1
- Amplifier—Type 3 ter
- Radio Set, Type E-10 bis
- Radio Set Type E-10 Artillery
- Radio Set Type E-3 bis
- Radio Set Type E-3 ter.

The Transmitting Set T. P. S. No. 2-bis, consists of a high power buzzer operated by a 10-volt storage battery with its secondary, as shown in the diagram, connected into a line of well insulated field wire whose ends for efficient operation were grounded by means

of metal stakes at points varying from 150 to 300 feet apart. The interrupter of the buzzer carried a slidable weight which could be used to vary the frequency of vibration from about 300 to 750 per second providing a distinctive note. Naturally no tuning was involved in the receiving.

The key was inserted in the primary circuit of the buzzer whereby it was possible to send pulses of alternating current into the ground where they spread out and set up currents in a similarly grounded line at the receiving station. Telegraphic signals were thus transmitted from one station to another. The maximum normal distance of reliable transmission by T. P. S. was about 2,000 yards. The receiving set T. P. S. comprised a low frequency three-step vacuum tube amplifier, whose circuits are shown in the diagram herewith, connected by insulated wire to a pair of ground stakes in the same manner as the transmitter. Inasmuch as audio frequency currents are set up by the transmitter no detecting action is necessary at the receiver. For best results the two base lines, or the line of ground stakes, of the transmitter and receiver should be parallel or approximately so, and laid out with the aid of a compass.

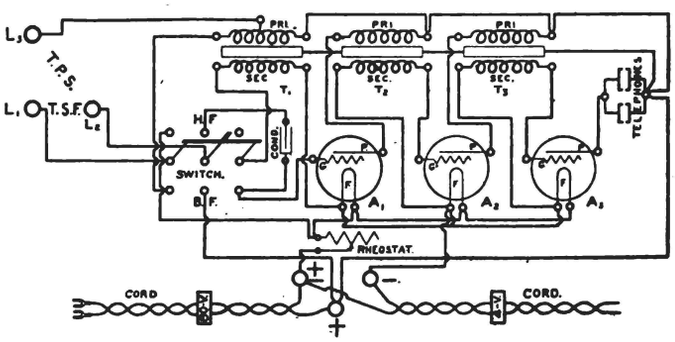


Circuit diagram of Transmitting Set T. P. S. No 2-bis

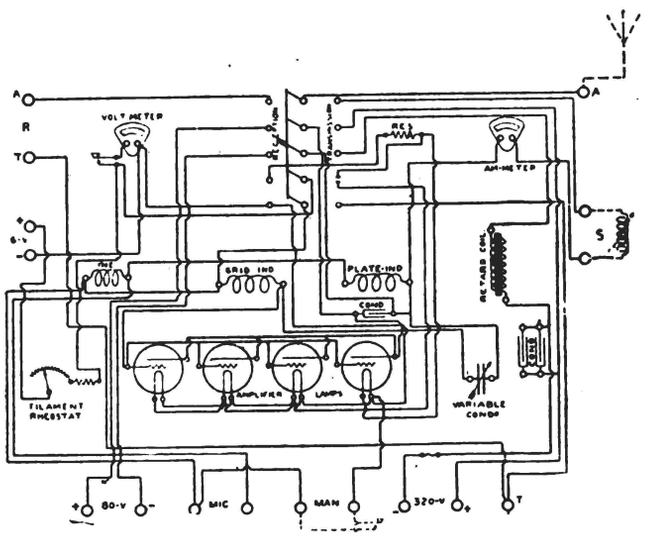
Receiving with Receiver Type A-1 and Amplifier Type 3 ter

The American equivalents of the French T. P. S. transmitter and receiver are known as S. C. R.-71 and S. C. R.-72 respectively. The two-way American S. C. R.-76 T. P. S. set was a combination of the two above types, which eventually would have replaced the French equipment, but it was never available in quantities for distribution to American Signal troops. It was considered superior electrically and mechanically to the French equipment.

The amplifier type 3 Ter.—a very useful piece of apparatus—was an integral part of any sets, such as, the receiving set T. P. S. and the E-3, E-3 bis. and E-3 Ter. sets. It was also a useful adjunct, as in connection with the receiving set type A-1. The amplifier 3-Ter. comprised three standard French vacuum tubes coupled by means of transformers—shown in the diagram—and supplied with current by storage batteries giving 4 volts for the filaments and 40 volts between plates and filaments. A rheostat in the filament circuit was the only means provided for varying the degree of amplification. Two leads were provided and a triple-pole double-throw switch for changing from connections whereby the amplifier acted as a low frequency amplifier for T. P. S. reception or for use as an amplifier, in conjunction with a crystal detector, to connections whereby the instrument might be used as a simultaneous detector and amplifier of radio signals. In this latter case the first of the three vacuum tubes acted as a detector and the other two as low frequency amplifiers. As soon as the availability of this amplifier became known to our operators, they immediately failed to get any results with their crystal detectors. Artillery operators complained that every time a battery fired the sensitive points on the crystals were lost and other stations complained that every time a shell exploded they were in the same predicament, no matter how far they might be from the disturbance. It was decided to restrict the use of the amplifier to simplify the storage battery supply which was required with them, but in the end nearly every spark



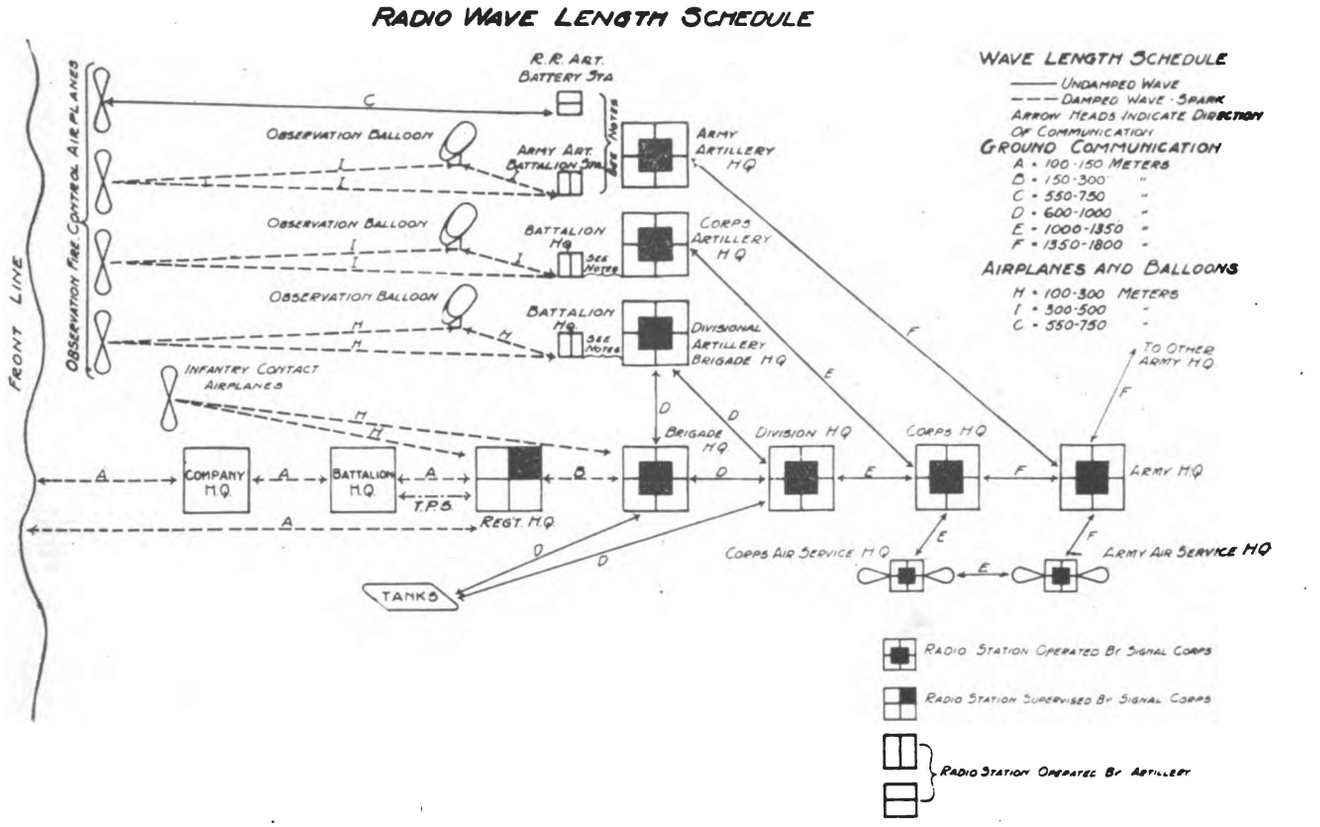
Circuit diagram of Amplifier Type 3-ter



Circuit diagram of transmitter and heterodyne for Radio Sets Type E-3, E-3 bis and E-3 ter

station had an amplifier and it must be admitted that the operators were probably justified in their attitude. Future practice of the Signal Corps will probably provide valve detectors and amplifiers with all spark receivers. As stated above the S. C. R.-72 was the American equivalent of this amplifier, except that it did not operate as a detector.

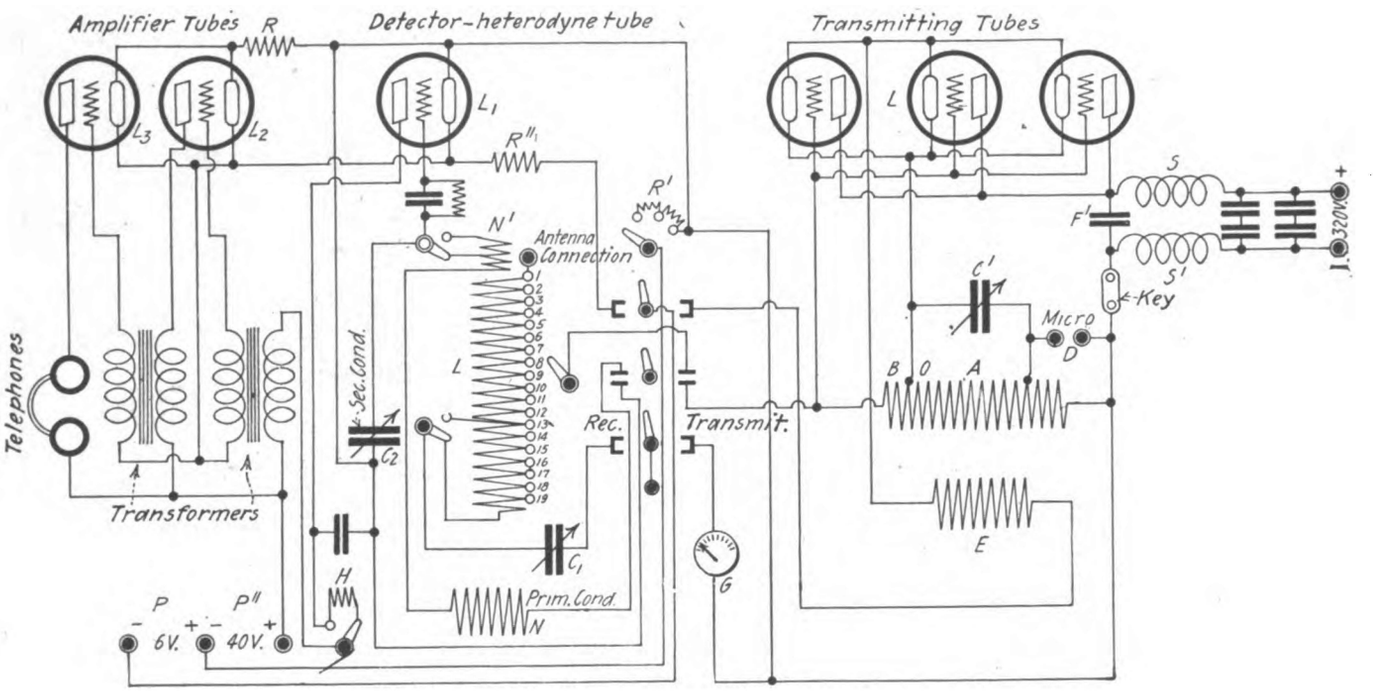
The receiving set artillery type A-1 was probably the most widely used piece of radio apparatus in the A. E. F. It was a simple form of receiver for damped waves, using crystal detector or the above amplifier with a wave-length range of 100 to 550 meters. It was practically fool proof, extremely simple to manipulate and available in large quantities. The receiver of this set comprised a box containing a primary and secondary circuit, as shown in the wiring diagram, each made up of a variable air condenser and an inductance. The primary coil was provided with four taps and the



Receiving practice with an American made SCR 54 Receiver and a French Amplifier Type 3 ter

secondary coil with five taps connected to the contacts of corresponding dial switches. The terminals of the primary circuit were connected to the ground and antenna respectively. Across the terminals of the secondary coil was connected the detector circuit which consisted of a galena crystal detector and a pair of telephone jacks, shunted by a small condenser. The secondary condenser was arranged to be cut out of the circuit by means of a switch, thereby making the secondary circuit a periodic for receiving signals of unknown wave-lengths. The receiving set Artillery type A-1 was complete with sectional bamboo antenna poles for the erection of a V type antenna.

The transmitting set portable type No. 4 which has been mentioned above consists of an induction coil,



Circuit diagram of Radio Set Type E-10 bis

as shown in the accompanying diagram, operated by a 10-volt storage battery which supplied about 3 amperes to the primary for efficient operation.

The spark gap in the secondary circuit of the coil is connected to the ground and antenna circuits directly. The antenna for use in the trenches consists of a single wire from 75 to 100 feet long stretched between two supports about 4 feet above ground. The interrupter should make about 100 vibrations per second. There is no provision for tuning and the wave-lengths emitted depend upon the length and height of the antenna. The radius of transmission was normally about 2½ miles under favorable conditions.

This set made many an American operator, who had long known this type of set as an amateur, decidedly homesick at first and then decidedly doubtful as to its utility in war. However, it had been adopted because of its simplicity and, with a slightly higher antenna which was possible at regimental stations, it could be relied upon for transmission over 5 or 6 miles. Its defects soon became evident and efforts were immediately started in the Radio Division to obtain better equipment for the front lines as the necessity for more reliable communication and sharper tuning became necessary.

The best undamped wave communication was probably obtained by means of the radio set E-10 bis, for the reason that it was the most compact and rugged of all the undamped wave standard French radio apparatus utilized by American signal troops. It is true that it had its disadvantages, but it can be said that it certainly was the most popular piece of undamped wave radio apparatus in the A. E. F. The E-10 bis set was designed to transmit undamped wave signals and receive either damped or undamped wave signals. Six standard French vacuum tubes were used, three for transmitting and three for receiving. In transmitting, oscillations are generated by three vacuum tubes operating in parallel as shown in the accompanying diagram, a potential of 200-320 volts being applied to the plate-filament circuit and 6 volts to the filaments. When connected to a horizontal V-shaped antenna, 29 meters on a side and supported 4 meters above the ground on bamboo poles, the set will transmit on wave-lengths ranging between 600 and 1,000 meters. For wave-lengths between 600 and 800 meters the lead from the apparatus to the point of the V should be 10 meters long; for longer waves it should be 12-15 meters long. This set could also be used with a single wire antenna 40 meters long including the lead to the set and supported 1 meter above the ground.

When used with the antenna described, a good ground and with 300-320 volts on the plates, the input into the antenna should be about 0.5 ampere for the short waves and 0.6 amperes for the longer waves. Under favorable conditions the efficient range between two sets was usually from 50 to 60 kilometers. The plate voltage for undamped wave transmission in general was supplied either by eight 40-volt storage batteries or by the American made 12-320 volt Westinghouse dynamotor which was furnished from the United States during the latter part of the war. Though only available in limited quantities, eventually all sets would have been provided with this efficient source of plate potential.

For receiving radio signals, damped or undamped,

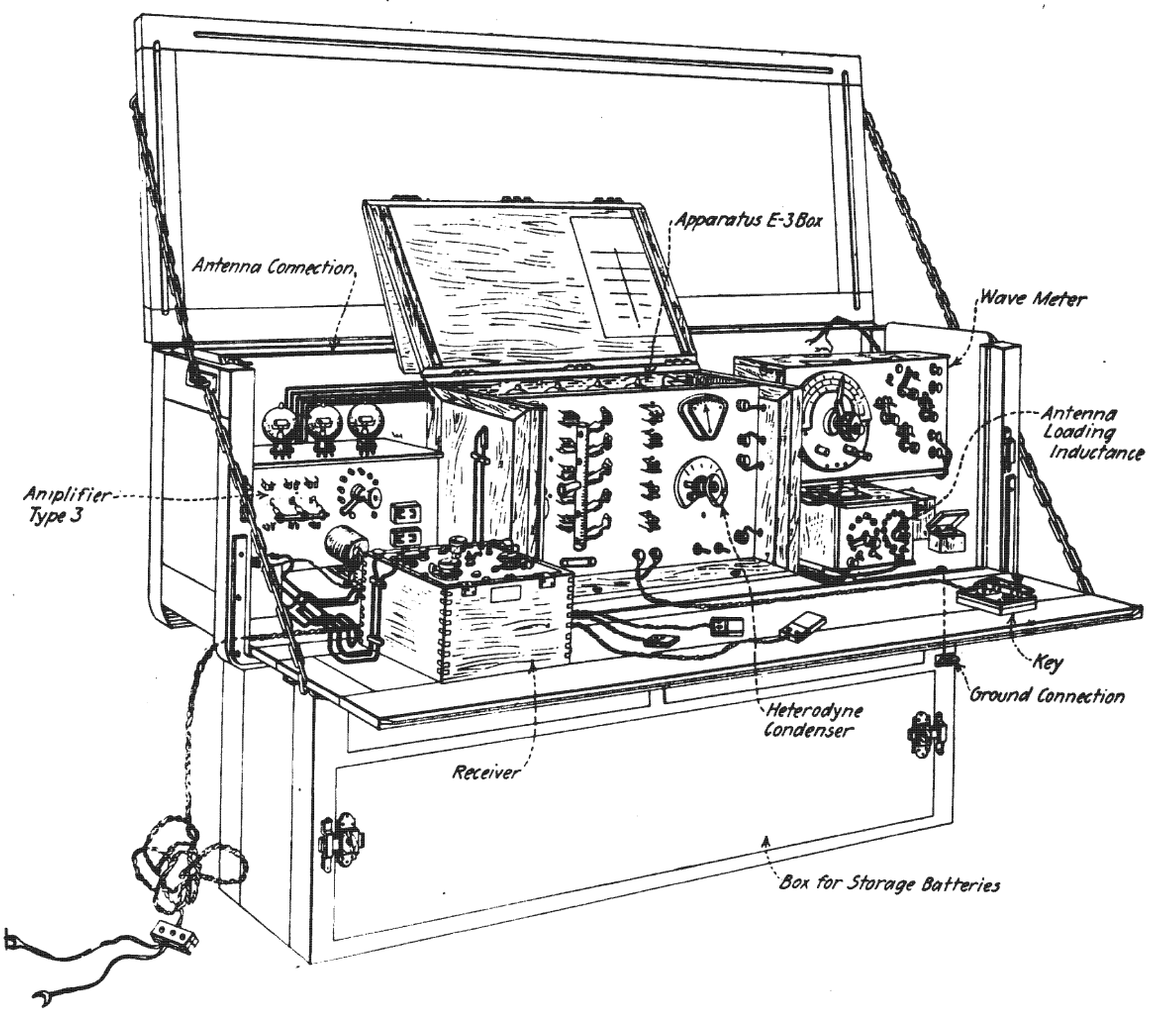
the E-10 bis set was provided with three vacuum tubes, as above described. When undamped signals were to be received one of the tubes acted as a detector and heterodyne, while the remaining two tubes amplified the detected low frequency signal impulses. The same 6-volt filament storage battery was used for both transmitting and receiving. The plate potential for the receiving tubes was furnished by a 40-volt storage battery. This storage battery should not be one of the series of 8-40 volt plate batteries used for transmitting.

An interesting piece of radio equipment which accompanied the E-10 bis sets was the wavemeter type T-1 which comprised a variometer and a fixed condenser, forming an oscillatory circuit, as against the fixed inductance and variable condenser commonly used. A small incandescent lamp was connected in circuit, as shown in the diagram, and was heated to a dull redness by a dry cell. The lamp served to indicate the resonance point when the transmitter was adjusted to the proper wave-length. A small buzzer in the wavemeter box may be used when it is desired to calibrate receiving circuits.

An American equivalent of the E-10 bis set was being developed in the United States at the termination of the war, but none were ever available to the A. E. F.

The series of E-3 sets—the radio sets E-3, E-3 bis and E-3 Ter—were practically identical in so far as design is concerned and the accompanying sketch may be considered as representative of this series of sets. The E-3 set became obsolete because its wave-length range 600-1,000 meters was assigned to the E-10 bis sets described above. The E-3 bis had a wave-length range of 1,000-1,350 meters and the E-3 Ter a range of 1,350-1,800 meters.

The accompanying schematic and circuit diagrams show the main features of these sets. Both the E-3 bis and E-3 Ter sets transmitted undamped wave signals and the continuous oscillations therefor were set up by four standard French vacuum tubes operating in parallel. Six volts is provided for the filament and 320 volts for the plate potential. These sets put about 6 to 8 amperes into the V-shaped antenna, 50 meters on a side with a 60° central angle and about 5 meters off the ground.

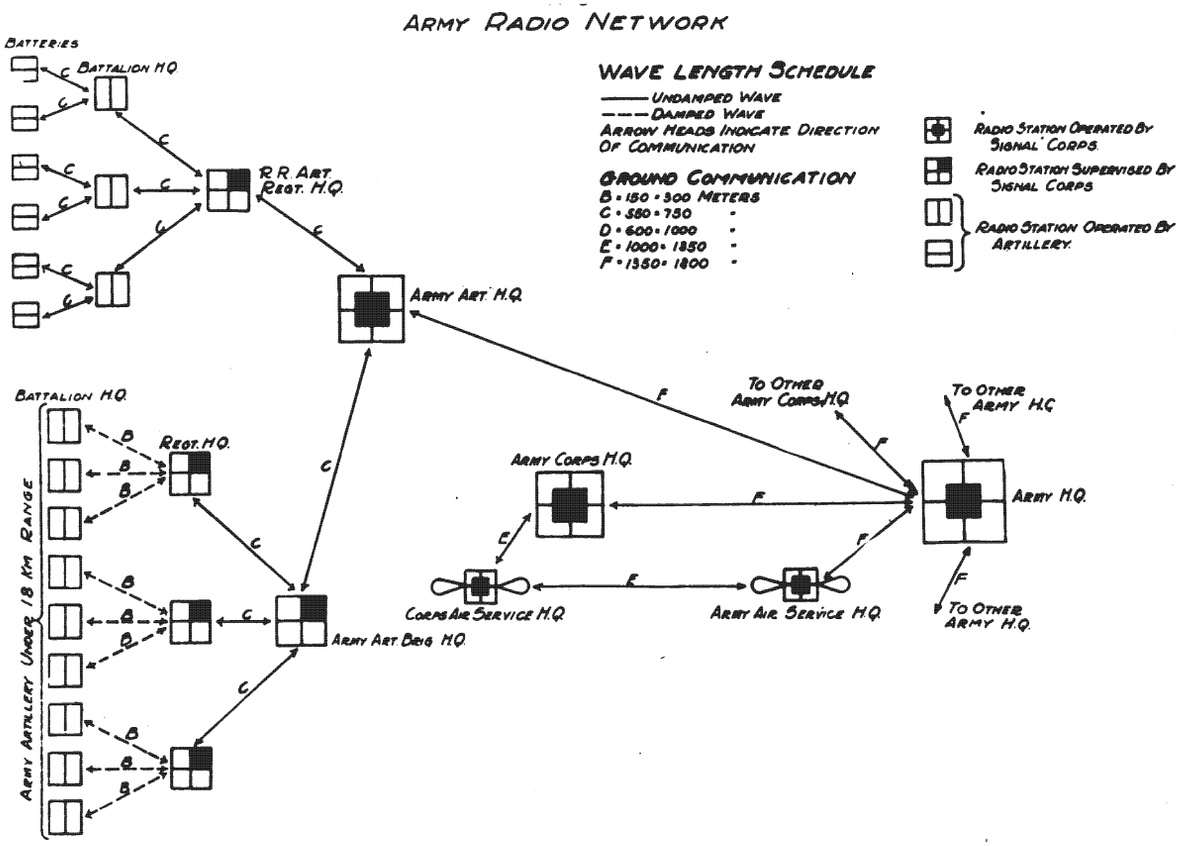


Sketch showing method of mounting the various component parts of Radio Sets Types E-3, E-3 bis and E-3 ter

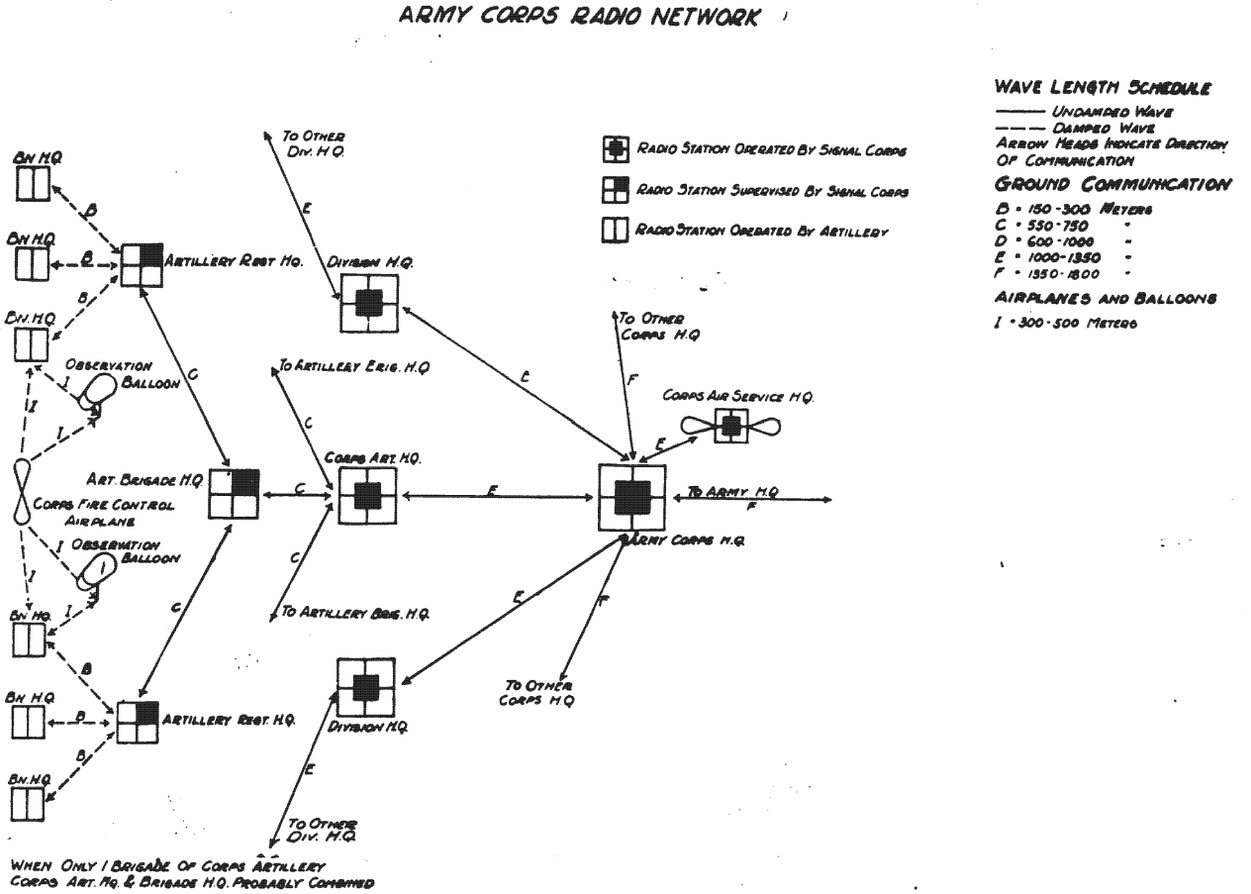
The E-3 bis and E-3 Ter sets were adapted to receive damped and undamped signals of a range of wave-lengths somewhat greater than that for transmission. The transmitting box circuit with one vacuum tube oscillating is used for the purpose of a separate heterodyne and the amplifier 3 Ter, as the detector and amplifier. The usual practice was to use 40 volts as the plate potential of the heterodyne tube.

Shortly before the signing of the armistice a new set was developed by the French known as radio set type E-13. This set was found to be very efficient in operation and was extremely compact, as compared to the bulky E-3 bis or E-3 Ter sets. The wave-length range was from 1,200-2,800 meters. It was

planned to reduce the lower figure to 1,000 meters in order that it might be used as a set to replace both the oscillations. It will be noted that the grid is coupled to the plate and also to the antenna loading inductance.



E-3 bis and E-3 Ter sets. The accompanying schematic diagrams show the circuit arrangements of this set. The maximum efficiency in the transfer of energy to the antenna is obtained by means of the arrangement

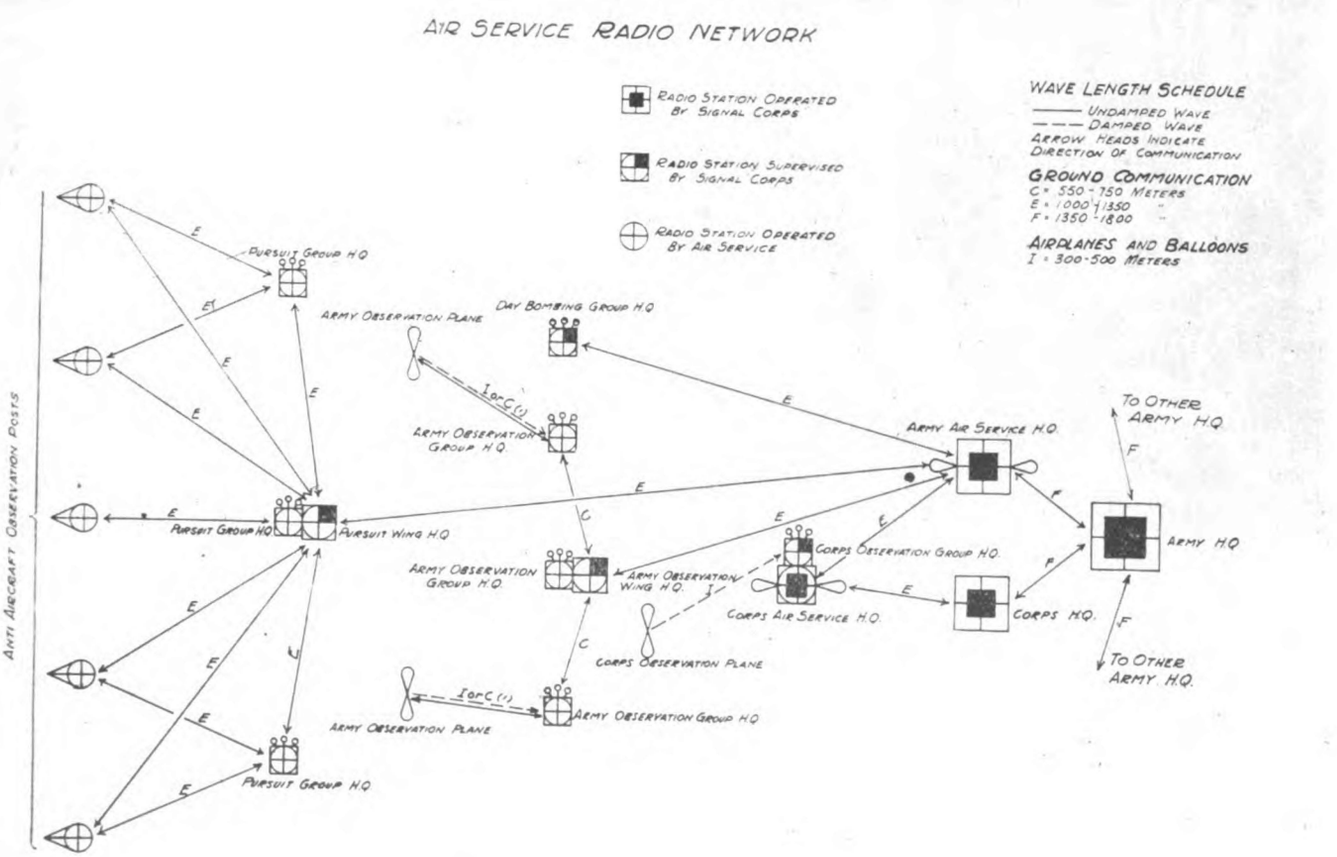


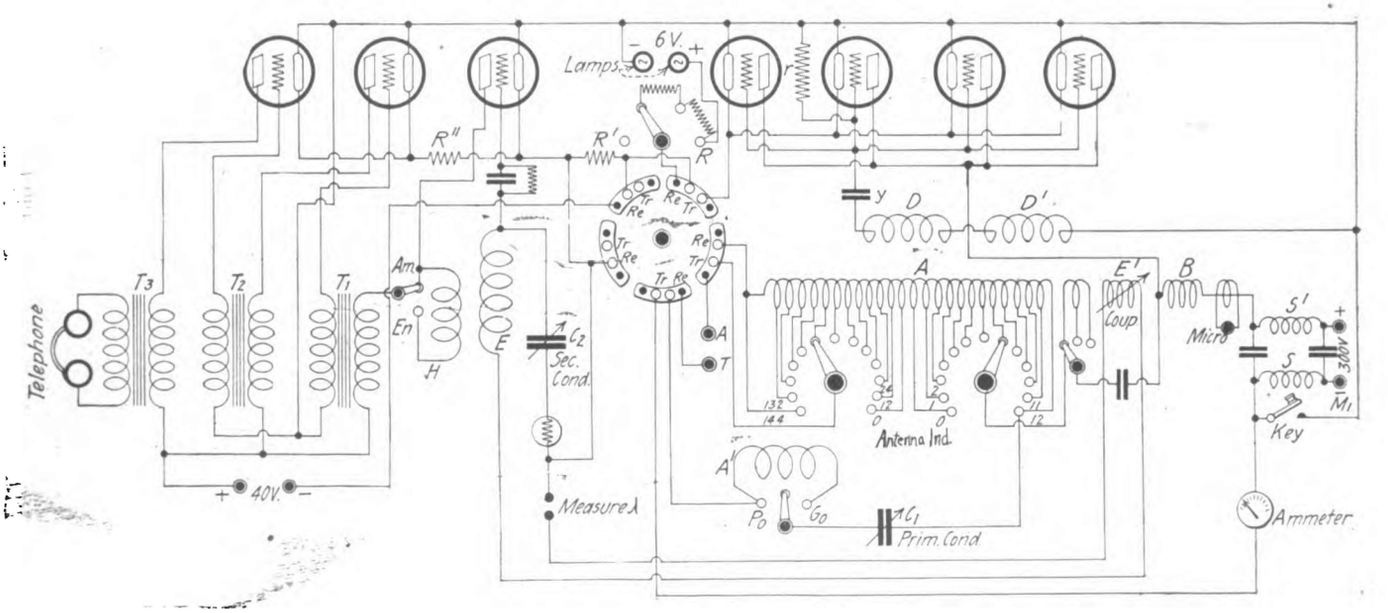
For transmission four standard French vacuum tubes operating in parallel generate the undamped of the antenna loading inductance A and a coil B in the plate circuit wound on the same ebonite tube. The

two grid coils D' and D are in series and link with the coils A and B respectively. The coil D' is placed within the coil A giving a close coupling and the coil D is outside and adjacent to the coil B being thereby loosely coupled to it. It is obvious that when the inductance in the antenna is increased the coupling between the coils D and A is increased. This arrangement makes possible a favorable value of coupling for all wave-lengths within the range of this set.

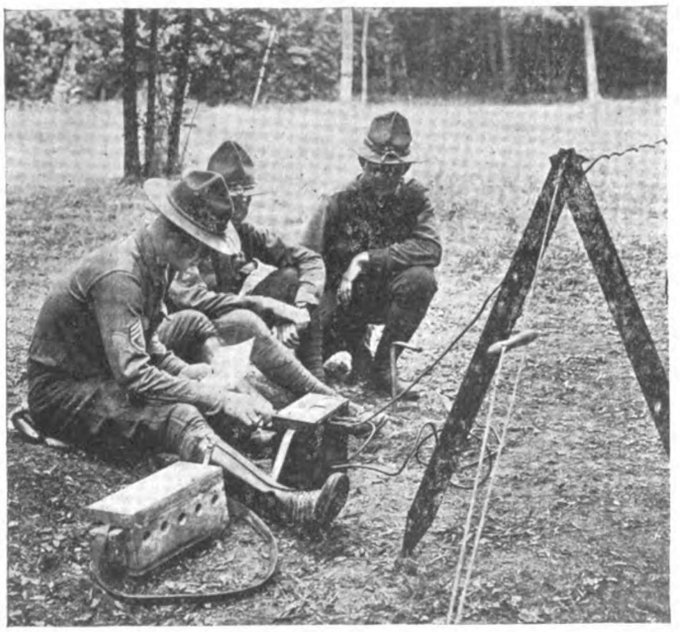
The coils S, S¹ and the condenser M¹ serve to smooth out current variations when a dynamotor is used to provide the 320 volts for the plate potential. The condenser N in the antenna circuit prevents the plate current from flowing in the antenna circuit.

A key in the plate circuit is used for telegraph signals and an auxiliary coil wound around the coil B and in series with a microphone permits the set to be used for radio-telephony, in which case the key is short circuited. For reception three standard French vacuum tubes are used for receiving either damped or undamped waves. When receiving damped wave signals, one of the tubes acts as a detector and the other two



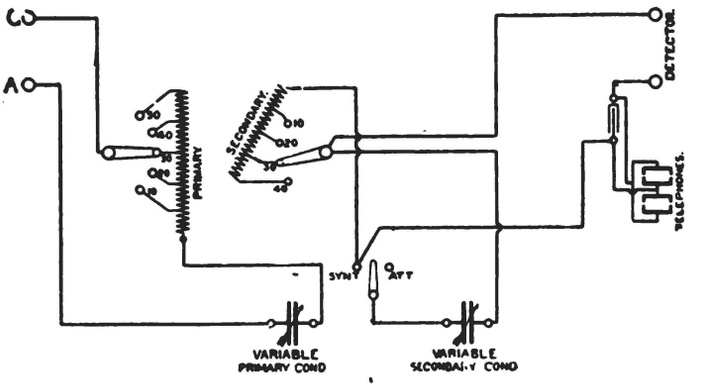


Circuit diagram of Radio Set Type E-13



Transmitting practice with Transmitting Set Portable Type No. 4

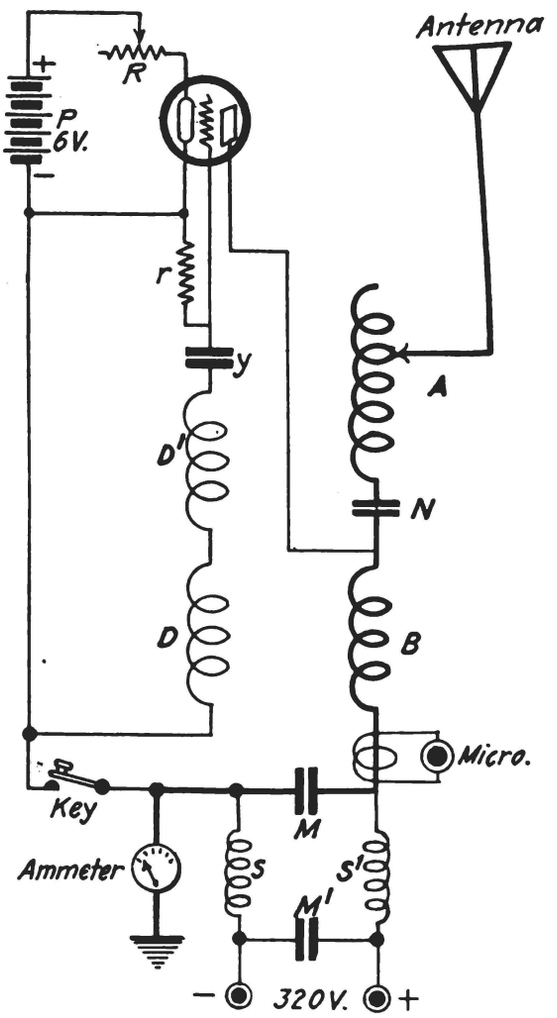
become low frequency amplifiers. It will be noted that the receiver secondary circuit comprises the variable condenser C-2 and two fixed inductances E and E. The inductance E is not coupled to the antenna circuit but it is mounted, together with the inductance A of the antenna, in the form of a variometer. Tuning of the antenna circuit is accomplished by means of the condenser C and by the inductance A^1 in series with the



Circuit diagram of Receiver Type A-1

inductance A. The coil A^1 may be entirely or partly used, or cut out of the circuit. When receiving undamped or continuous waves the coil H coupled to the coil E serves to maintain the local oscillations by the tube L for heterodyne reception. The coil H may be cut out of the circuit when damped waves are received. The tubes L-2 and L-3 comprise a low frequency amplifier and they are coupled by the transformers T-1 and T-2. The telephones are coupled to the plate circuit of the tube L-3 through the transformer T-3. The commutation switch provides for rapid changeover from receiving to transmitting.

It will be noted by reference to the circuit diagrams of the French undamped wave vacuum tube sets, that provision was made for radio-telephony, the sets being



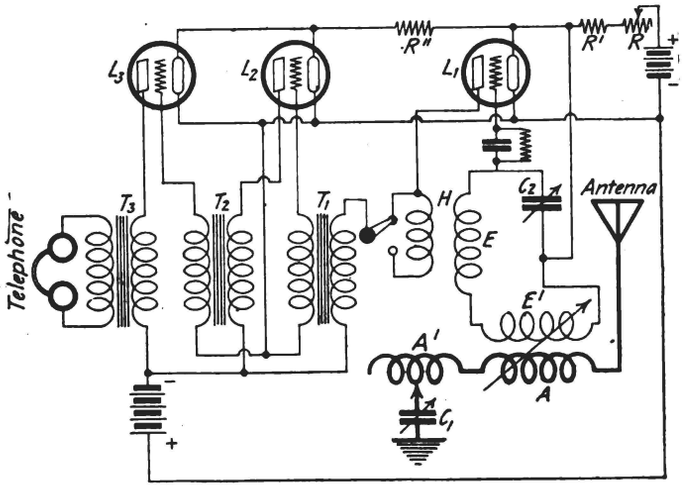
Simplified diagram of Radio Set Type E-13 transmitting tube circuit

A Ford Radio Tractor, Divisional Headquarters Radio

fairly efficient though never so used in the armies. We have already indicated the difficulty in suppressing indiscreet language over wired telephone circuits where theoretically, at least, they could be made secret. It need not be explained what would have resulted if radio-telephony had been utilized to intercept stations the Germans were operating against us. The

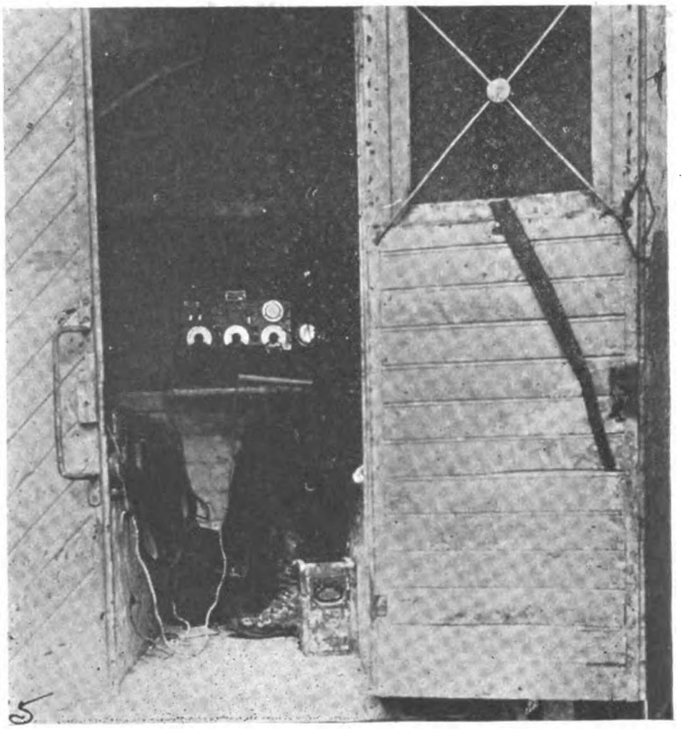
slang phrase "I'll tell the World" would have had a real meaning in that case.

This article outlines in a technical way the offensive or communication radio service in our army. It does



Simplified diagram of Radio Set Type E-13 receiving tube circuits

not picture the problem of the individual stations or their operators, who by their efforts made their particular station efficient and reliable and thus contributed to the successful entity. Imagine yourself the operator of a regimental or brigade headquarters station located in a muddy dugout, with a gas curtain over your dugout entrance and you with a gas mask on trying to get a message through, hoping the next shell doesn't take away your antenna, or that you are the operator of a station in an abandoned French home in a tiny village, or in the kitchen of an old stone house which could not have been very comfortable at its best, but now damp, cold and bare of everything that suggests a human habitation, is your combined workshop and habitation. If it is winter it is cold



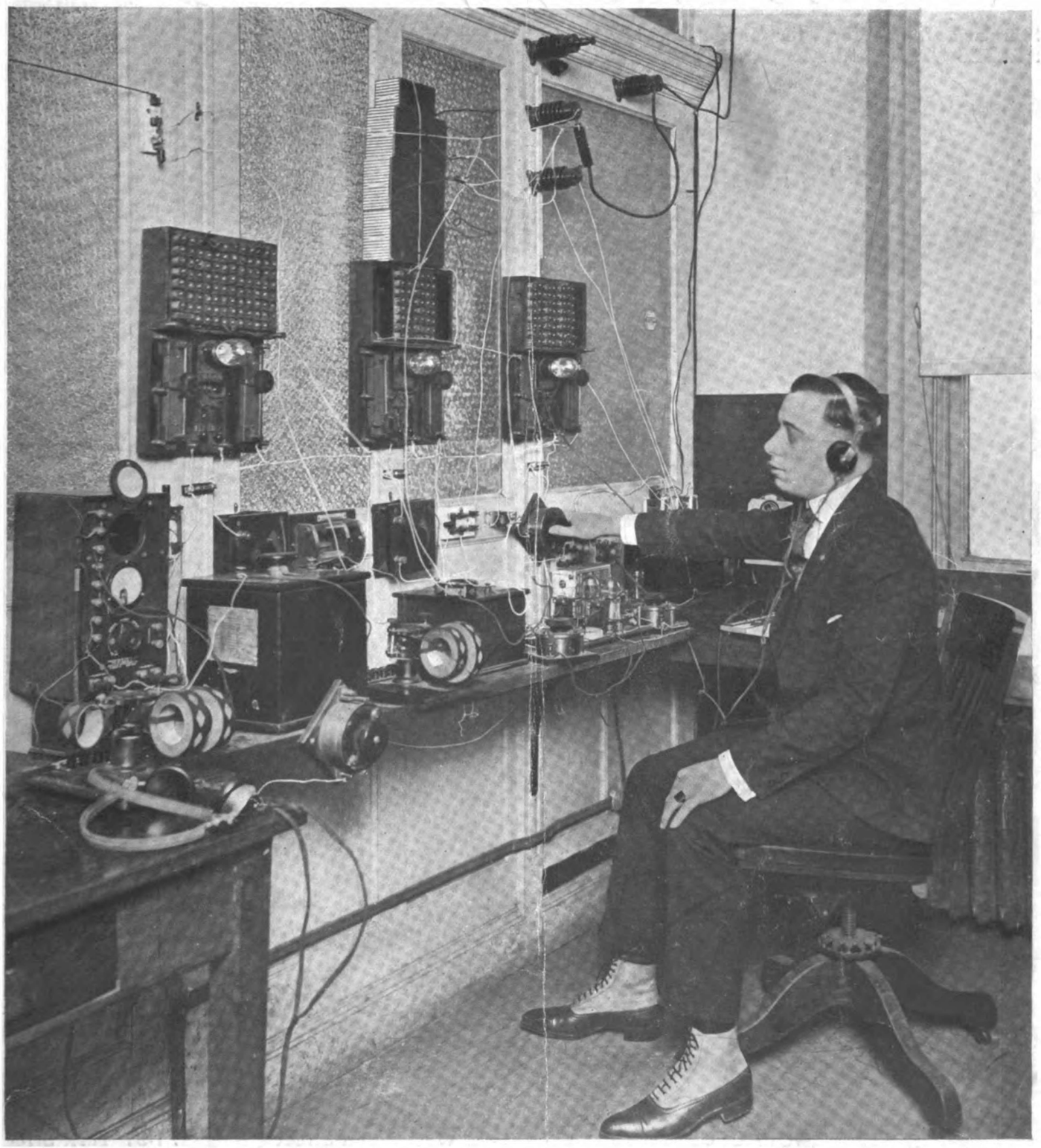
View showing interior of Fiat Tractor in which was mounted both an E-3 bis Set and an E-10 bis Set. The E-10 bis equipment can be seen through the open door

and clammy and you yourself are covered with the grey mud of northern France. This is not a very encouraging condition under which to operate your station, but it may at any moment become the only means of communication and you are always one of the important links that make the various networks outlined above effective. You are left mainly on your own responsibility, your personal trials and tribulations would make interesting reading, but unfortunately they could not be recorded in this article.

January, 1920 20 Cents

The WIRELESS AGE

Volume 7 Number 4



An Experimental Set in New York which receives signals from stations a mile away and across the ocean at the same time

Radio Intelligence in the Army

Third Article of a series on Wireless in the A. E. F.

By Lieut. Col. L. R. Krumm and Capt. Willis H. Taylor, Jr.

Wireless in the A. E. F.

First Authentic Account of the Organization of the Radio Division of the Signal Corps and an Inside View of the Great Obstacles Which Americans Had to Overcome

By Lieut. Col. L. R. Krumm

Officer in Charge Radio Division, Signal Corps, A. E. F.

and Capt. Willis H. Taylor, Jr.

Co-ordination Officer, Radio Division, Signal Corps, A. E. F.

Part III

IT can reasonably be said that every move the enemy made after January, 1918, was observed and followed by American radio intercept, radio goniometric (compass stations) or ground listening stations. Intelligence of the greatest value concerning the enemy's plans and disposition of his troops was deduced from these intercepts and observations.

This source of information, so cleverly developed by the French and British, was utilized and improved to such an extent that toward the close of hostilities it was one of the most trustworthy aids to the operations of the American army. Information was obtained by these means which could not have been secured in any other manner, and the stations also continually served to check information received from other sources.

It was through information furnished by the radio goniometric stations that we had the ability to locate accurately every German radio station in the St. Mihiel salient on the days preceding the attack of September 12, 1918. The operation of the German stations furnished the only proof that the enemy had not withdrawn from the salient, and this proof—even in the face of overwhelming evidence to the contrary—prevented an eleventh hour change in the plans for the attack and a possible change in results.

The operation of the radio intercept and radio goniometric stations and T. P. S. (ground telegraph) and wire telephone listening stations and the forwarding of all data to the Intelligence Section of the General Staff, A. E. F., was performed by the Radio Section (Intelligence) of the Radio Division, Signal Corps. In the words of the Intelligence Officer of the First American Army, "upon the efficiency of the Radio Section depended, in large part, the success of the Intelligence Section of the General Staff."

Unceasing vigilance was required of the officers and men of the Radio Section, together with the ability to meet the myriad ever-changing conditions. Too much credit cannot be given to the enlisted personnel. The trying conditions under which they labored, and the important results achieved by them were bywords to all who had knowledge of this service.

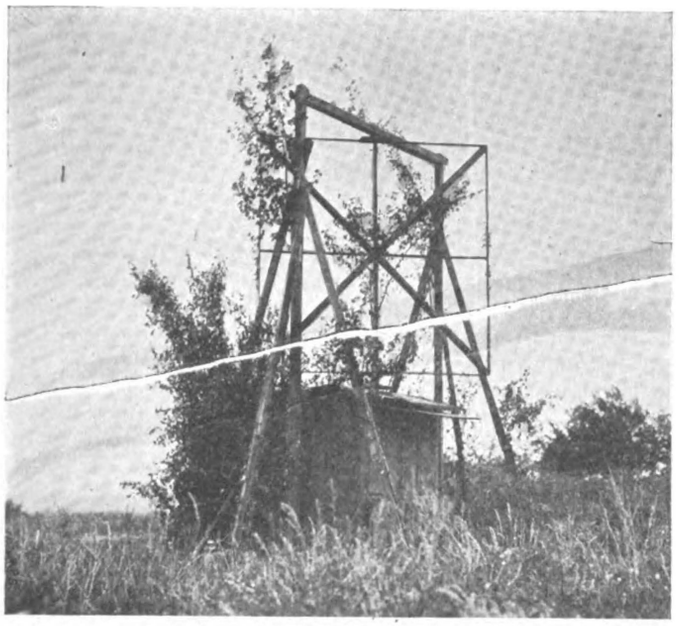
The Radio Section operated stations of six separate and distinct kinds, as follows: radio intercept stations which copied messages, generally in code, transmitted from German ground-radio stations; control stations which supervised the work of American radio stations and reported and stopped the use by our own forces of "clear" (uncoded) English and prevented other dangerous practices that might have served a useful purpose to the enemy; goniometric or radio compass stations which secured bearings on enemy radio stations, the

Radio goniometric station at Froidos in the Verdun sector

Radio intercept station at Ansauville in the Toul sector

Radio goniometric station at Landrecourt in the Verdun sector

transmittal of this data, enabling the Intelligence Section (General Staff) to accurately locate the stations geographically; airplane intercept stations which copied messages transmitted from enemy planes to the enemy ground radio station; airplane goniometric stations which located enemy observation and radio fire control airplanes and sent the bearings immediately to the Air Service, which in turn sent our pursuit planes to destroy or drive



Camouflaged radio goniometric station on the Toul front

the enemy planes behind their lines; listening stations, which copied telephone and T. P. S. (ground telegraph) messages, thereby securing valuable information from enemy communications and at the same time policing our own telephone lines to see that dangerous conversation was not held over accidentally grounded circuits. The work of listening stations will be more fully described in another article of this series.

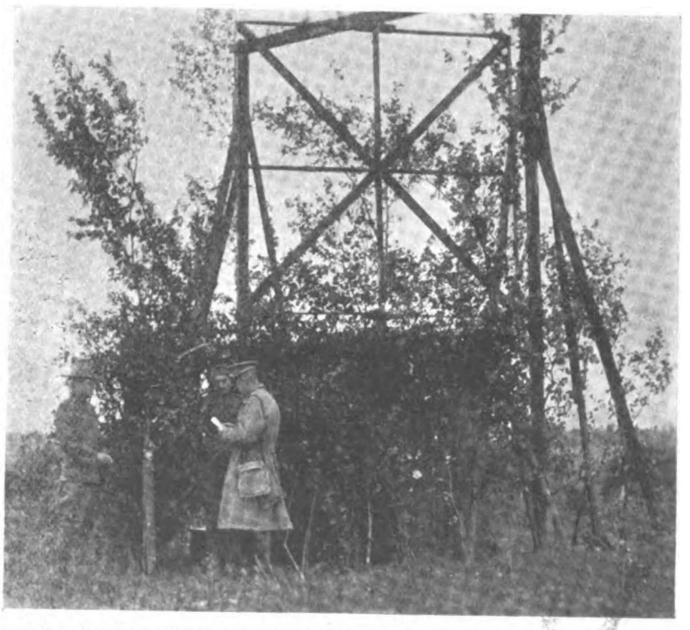
Before passing to the description of the apparatus used in the various types of stations and to outline the organization of the Radio Section (Intelligence), the following incidents may be of especial interest. They represent only a few of the many scoops that were made in addition to the daily confirmation of the enemy battle order, which may be briefly explained as the identification of the German units then in the trenches before us. Frequently the relief of a certain German unit was discovered before it had left the communication trenches.

On March 11, 1918, an entirely new code was put into service by the Germans. This was considered of great importance and indicated that the long-expected German attack would soon take place. All available officers and men of the Intelligence Section (General Staff) were assigned to its solution. On March 13, 1918, a message in an old solved code was intercepted by one of our radio intercept stations of the Radio Section (Intelligence). It was from a German radio station which had received a message in the new code and stated that the addressee was unable to read the message but asked that it be repeated in the old code. From the call letters given in this message it was possible to find the original message in the new code and the repetition in the old code, both having been copied. Comparison of the two gave a number of solutions which were at once communicated to the British and French intelligence sections. With this as a start, rapid solution was assured, so that before the Germans themselves were really familiar with their own new code it was being decoded by all of the Allies. The importance of the solution of this new German code can hardly be overestimated.

When it is considered that the message copied appeared to the radio intercept station operator simply as a series of letters without meaning, which is the hardest type of message to copy, and that in order to be sure of getting the valuable messages it was necessary to copy several hundred useless ones each day over long periods of time, also that the copying was done under difficult conditions and through interference which would have confused all but the best operators, then it will be possible to appreciate the fine work done by the men of the Radio Section. In this one instance a few minutes of inattention, a single mistake in call letters or the missing of a few groups of the code in one of the messages would have made the other useless. The American operators were the only ones who copied all three messages with sufficient accuracy to be useful, thereby enabling us to lay claim to the credit of performing this vital service for the Allies on the western front.

On the afternoon of April 24, 1918, a German message was intercepted from the St. Mihiel sector, announcing that an enemy attack had been postponed on account of bad weather. At 1.25 p. m. and again at 1.32 p. m on April 25, messages were again received ordering the German artillery batteries to remain at absolute attention and announcing that the barrage signal would be "BLUE." Our troops were notified and the necessary steps were taken to successfully combat the enemy raid which took place that night.

At 9.05 p. m. on April 28 a German message ordering an attack in the Toul sector at 1.00 a. m. was intercepted and telegraphed to the Intelligence Section (General



Radio division officer inspecting a camouflaged goniometric station on the Toul front

Staff) decoding office, where it was decoded and our troops were warned thirty minutes before the attack. Without a well organized system for copying and transmitting these messages this information would have been received too late to have been useful. It should be noted that in this case, as in others, the radio intercept station operators had no knowledge of the important nature of the message.

Again on June 14, 1918, a German message was intercepted stating that the French were preparing an attack and giving instructions for meeting it. The French Army Staff was notified. We were later informed by the French

that they had planned an attack at the designated point and that our information that the Germans were prepared for it enabled the French to take the necessary precautions.

The radio goniometric stations (radio compass stations), like the intercept stations, performed excellent work; in spite of daily changes in the call letters of enemy stations they located accurately nearly all the enemy radio stations. The care and accuracy shown by the operator enabled the Intelligence Section (General Staff) to follow the movements of the German stations with precision and certainty. These movements often disclosed the intentions of the enemy.

The first radio intercept and goniometric station at General Headquarters, A. E. F., at Chaumont

One case in particular is very interesting. Just before the American attack on the St. Mihiel salient there were many indications that the enemy had withdrawn and the advisability of advancing the infantry without artillery preparation was seriously considered. The final decision to make the attack as originally planned was based upon the observations made by radio goniometric stations that enemy radio stations were still active in their old locations.

The airplane radio intercept stations also gave an excellent account of themselves by reporting the location of enemy radio fire control airplanes working with the German artillery, enabling the various American Air Service Squadrons to interfere with many well planned hostile "shoots," as a local radio controlled artillery action was termed.

The first American radio intercept station was established at Souilly in December, 1917, at the Headquarters of the Second French Army, which was defending the Verdun sector. Due to the inexperience of the men it was difficult, at first, to obtain satisfactory results, but after a few weeks they became so proficient that the Intelligence Section of the Second French Army requested copies of all messages intercepted by this station. On New Year's Day, 1918, another intercept station was established at Souilly, one station serving to copy short-wave German stations and the other long-wave German stations. These stations were soon moved, one to Landrecourt and the other to Froidos, both towns being a short distance back of Verdun.

After the First Division had taken over a portion of the front northwest of Toul, intercept stations were established at Ansauville, eight kilometers from the battle front. After a few months of bombardment and gas in this location the stations were moved to Menil-la-Tour and then to Toul, where better wire connections to General Headquarters A. E. F. could be secured. In the meantime the radio intercept stations at Froidos and Landrecourt were moved back to Souilly, First Army Headquarters, where they remained until the advance of the First Army on the Argonne front made it necessary to move them forward.

Most of the radio intercept operators had their share of thrills. For two weeks the Germans were endeavoring to destroy an ammunition dump located about a quarter mile from the intercept station at Landrecourt and about six miles from the lines, requiring the Germans to use a heavy calibre gun to reach it. A number of these huge shells landed in close proximity to our stations, throwing shell fragments and stones into the station huts. The operators stuck to their posts during these bombardments, although no protection whatever was afforded them. The dump was finally hit and exploded, its force breaking the oiled cloth windows of the radio station hut and upsetting a storage battery on the head of the operator. This man thereupon showed his courage by calmly replacing the heavy battery and continuing to copy.

Following the formation of the Second American Army in October, 1918, the Radio Section Base was established at Toul, with detachments operating in both the First and Second Armies. The First Army detachment moved its headquarters and intercept stations to what was known as "Radio Hill," near Essey, while the Second Army detachment established stations and quarters in dugouts formerly occupied by the enemy, on the crest of an eminence six kilometers from the line and overlooking the entire front of the Second Army. When the First American army pushed ahead in the Argonne, the intercept stations at Souilly were moved forward and installed on the top of the citadel at Verdun. This location afforded a perfect target for the enemy artillery. Gas alarms were an everday occurrence, antennæ were cut down and the stations were showered with shrapnel.

The equipment in the radio intercept station comprised standard French radio intelligence apparatus, together with some specially designed Marconi receivers which gave excellent results. The French equipment was known by the following names:

Fort Landrecourt forming portion of Verdun defense as seen from radio intelligence station at Landrecourt

Receiver Type No. 2.
Receiver Type No. 3.
Receiver Type A-1.
Amplifier Type 3-ter.
Amplifier Type L-3.
Amplifier Type R-2 bis.
Amplifier Type R-3 ter.
Wave Meter Type No. 2.

Receivers, Types No. 2 and No. 3, each consisted of a primary and secondary circuit made up of a variable

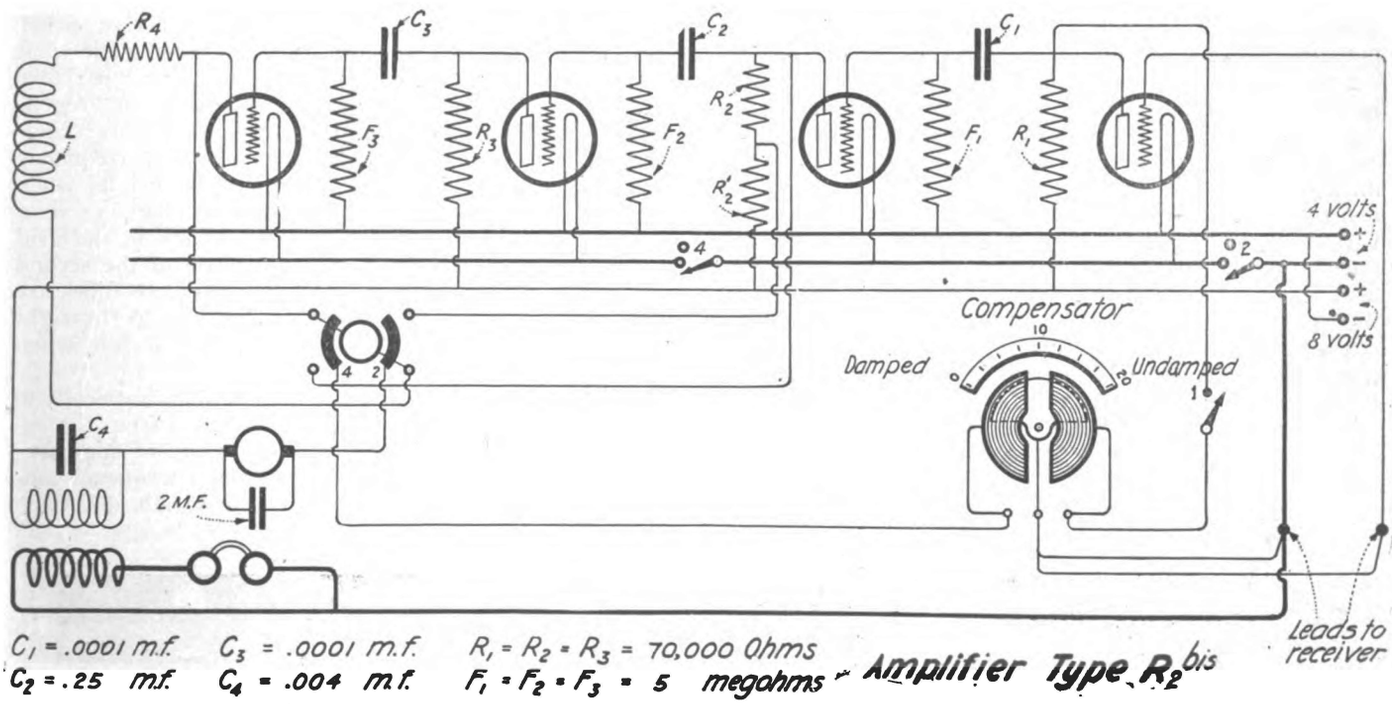
Radio goniometric stations on Toul front provided with small loops of American design

capacity and a variable inductance as shown in the circuit diagrams. The secondary of the Receiver Type No. 2 is arranged so that the coupling between the primary and secondary circuit may be varied by pulling out a movable section of the receiver box upon which the secondary inductance is mounted. A four-point switch on the panel makes it possible to connect the secondary circuit directly into the antenna for stand-by listening or to inductively couple it with the primary circuit for tuning purposes. Multi-point switches are provided for primary and secondary inductances by means of which the desired number of turns may be used in both the primary and secondary inductances respectively. Numerous auxiliary switches are provided on both multi-point switches to disconnect the unused portions of primary and secondary inductances in order to avoid the absorption of energy by setting up oscillation in such unused portions or dead ends. By means of two switches, fixed condensers may be connected in shunt with the variable condensers of the primary and secondary circuit.

The Receiver Type No. 3 is similar in both electrical and mechanical construction to Receiver Type No. 2 with the exception that the coupling between the primary and the secondary inductances is varied by rotating a portion of the secondary inductance within the primary inductance. Receiver Type No. 2 is designed to be utilized on wave lengths from 150 meters to 6,000 meters and Receiver Type No. 3 from 300 meters to 15,000 meters.

Both the Receiver Type A-1 and the Amplifier Type 3-ter have been described in a previous article.

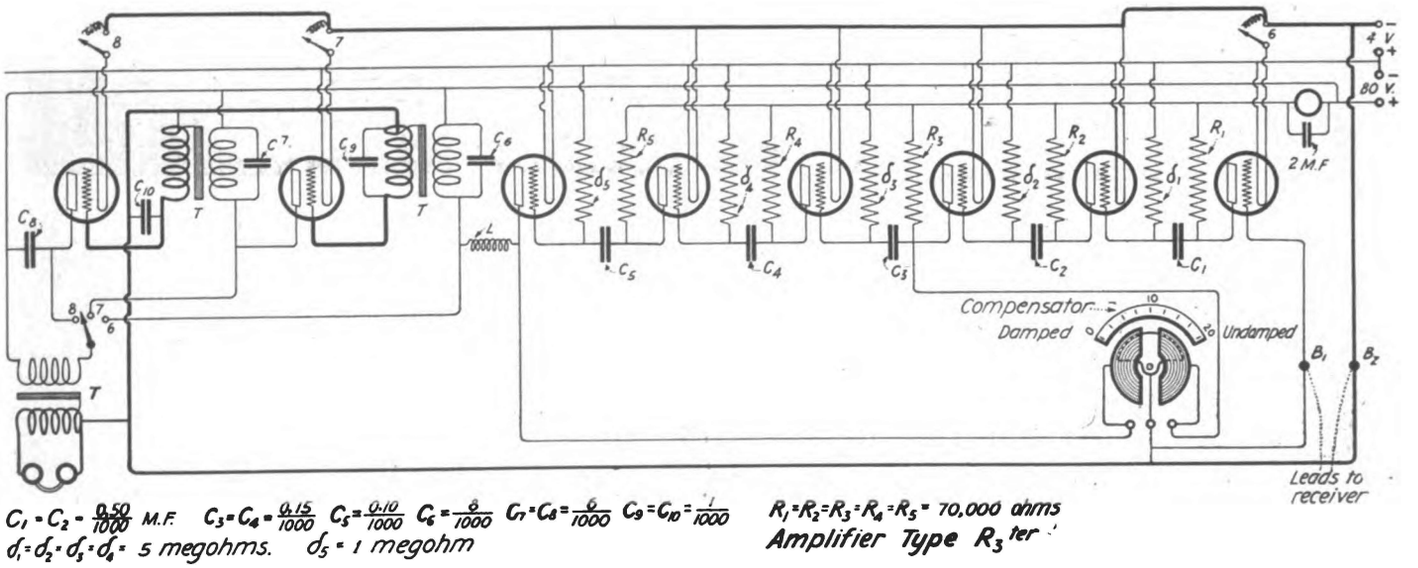
The Amplifier Type L-3 was used principally for receiving on loops; a description of this instrument will be given hereafter in connection with the radio goniometric station equipment.



Circuit diagram of Amplifier Type R-2 bis

Amplifier Type R-2 bis comprises four standard French vacuum tubes, as shown in the accompanying circuit diagram, coupled by means of high non-inductive resistances. All four tubes may be used in series, or the last two tubes may be cut out of the circuit. With four tubes it works best on wave lengths above 800 meters.

while with only two tubes in operation it may be used to receive efficiently wave lengths as low as 400 meters. The Amplifier R-2 bis was designed particularly for the reception of weak signals. The accompanying simplified circuit diagram will aid in an understanding of the complete diagram; all of the vacuum tubes being connected in the same way. In this diagram it will be seen that the grid is connected by means of a resistance to the



Circuit diagram of amplifier Type R-3 ter

positive lead of the 4-volt filament battery. The grid potential between the points C1 and C2 charges the grid condenser which in turn imparts its charge to the grid in the usual manner, giving rise to variations in the filament plate current. The plate is connected through the resistance R to the positive lead of the 80 volt plate filament circuit B battery. The potential drop through the resistance R therefore takes place in accordance with variations of the plate current and therefore high frequency amplified oscillations are available. There is also a simultaneous detecting action carried on and the proportion of the two effects depends upon the strength of the signals received. The high frequency amplifying effect will be preponderant for weak signals, while the detecting effect is the greater on strong signals. The result is that for the circuit arrangement described a single vacuum tube so connected will work well on strong signals as evidenced by the telephone, but it will not work well on weak signals, although the high frequency amplifying effect may be very great. This defect is avoided by connecting several vacuum tubes in series, the first vacuum tubes then acting as high frequency amplifiers for weak signals and the last one almost solely as a detector. It will therefore be observed that this amplifier is particularly adapted for receiving weak signals. It also aided considerably in eliminating strong static.

The amplifier R-2 bis is arranged to receive either damped or undamped waves. It is provided with what the French term a "compensator," which in our parlance is familiarly known as a "capacity feed back" or "regenerative coupling." Briefly, the purpose of this "compensator" is to maintain the production of high frequency local oscillations on the self-heterodyne principle, when receiving undamped waves. When four tubes are used it couples the plate of the fourth tube back in the grid of the first tube, while it couples the plate of the second tube in the grid of the first tube when only two tubes are used. The compensator's pointer should be to the right when receiving undamped waves and to the left when receiving damped waves.

The Amplifier Type R-3 ter is very similar electrically to Amplifier Type R-2 bis, as will be observed from the accompanying diagram, but it has six steps of high-frequency amplification and two steps of low frequency amplification. This makes a total of eight standard French

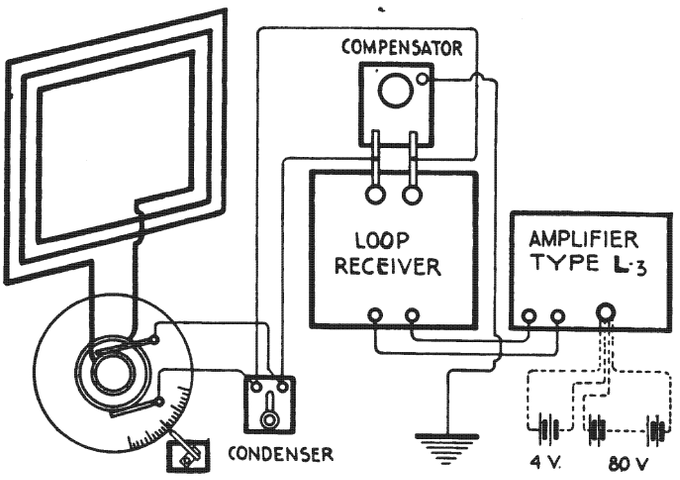
Operator copying short wave length radio intercepts in Toul sector

Locating German field station in a radio-goniometric station on the Toul front

Copying coded German messages in a long wave length radio intercept station on the Toul sector

vacuum tubes used in its construction. As in the Amplifier Type R-2 bis, the last vacuum tube of the high frequency amplifier serves as a detector. The two last vacuum tubes serve only as low frequency amplifiers of the amplified and rectified audible frequency signal impulses.

This amplifier may be used to receive signals on wave lengths varying from 2,000 meters to 20,000 meters for either damped or undamped waves. Further explanation of the function of the so-called compensator will be omitted, as it has been explained in connection with the Amplifier R-2 bis. Attention is directed, however, to the fact that when undamped waves are to be received the



Circuit diagram of a radiogoniometric station

plate of the sixth vacuum tube is coupled back to the grid of the first tube.

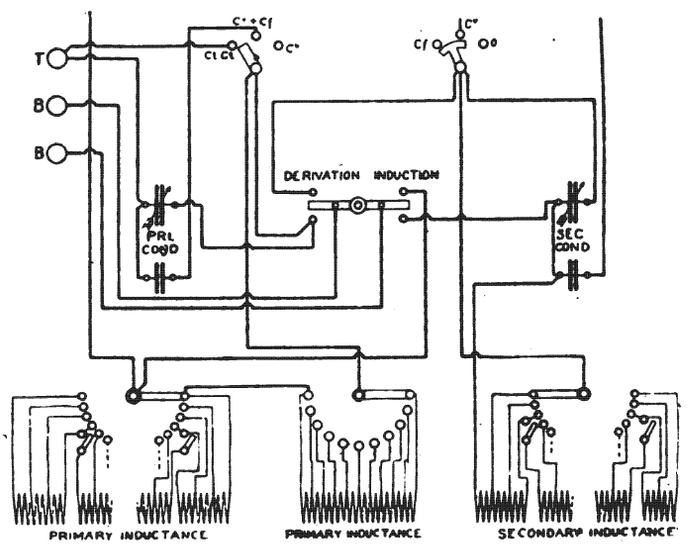
Provision is also made in Amplifier Type R-3 ter to utilize a variable number of vacuum tubes. A switch is provided whereby six, seven or eight lamps may be utilized, which means that no low-frequency amplification may be provided or that one or two steps may be used in accordance with the desires of the operator.

The most generally used wavemeter for calibration purposes in radio intercept stations was that known as Wave-Meter Type No. 2, and it was adapted to be used for a wave length range of 150 meters to 1700 meters. A few of the novel features of this wave-meter will be observed in the accompanying circuit diagram. The calibrated circuit comprises two inductances, the first in three sections and a variable condenser with a pointer moving over an arc graduated in wave lengths. Three scales of wave length are engraved on the arc, corresponding to the cases when one, two or three sections of the first inductance are connected into the calibrated circuit. The buzzer circuit is closely coupled with the first inductance of the calibrated circuit, serving to set up oscillations in it. By means of a double switch the coupling coil of the buzzer circuit may be cut out and the buzzer be made to serve as a "tikker," periodically breaking and closing the calibrated circuit, for the detection of undamped waves. The detector circuit has two coils wound on the same spool placed inside the first inductance of the calibrated circuit. A double, three-way switch makes it possible, first, to connect the two coils in series opposing for measurements of emitted waves (position Em); secondly, to connect in one coil alone for the reception of short waves (position PO); third, to connect the two coils in series, aiding for the reception of long waves (position GO). An auxiliary coil which can be connected into the antenna circuit more or less closely with the calibrated circuit is made up of two coils, the second of which is used for increasing the coupling for the longest waves.

The service performed by the radio goniometric stations was closely allied with that of the radio intercept stations, inasmuch as the determination of the point of origin of a German message which had been copied by our radio intercept stations aided the Intelligence Section of the General Staff in the preparation of their charts of German radio activity and helped to locate the concentration of German troops in different sections of the line.

The work done by our radio goniometric stations was greatly facilitated by the adoption of a small revolving frame to replace the somewhat cumbersome French frame. The smaller frame was found to be much easier to rotate, especially while working in a heavy wind. The operators were enabled in this way to obtain more bearings, with improved accuracy, while the intensity of the signals remained about the same.

In addition to our radio intercept stations radio goniometric stations were established at Froidos and Landrecout during January, 1918, and in March a station was installed at Ansauville in the Toul sector. The Ansauville goniometric station being located in a very dangerous position, it was later moved back to Menil-la-Tour. This station while at Ansauville and Menil-la-Tour was the first radio goniometric station operated by Americans in an "All American Sector." During an attack on the Toul front on May 27, 1918, it was operated by two men for the 24 hours of a day and took 650 bearings, thus establishing a record that was never subsequently beaten or even equaled. To understand what this figure means, one should have had actual experience in operating a gonio. In order to take one bearing it is necessary to tune in the calling station by manipulating the adjusting knobs of the loop receiver with one hand, while rotating the revolving frame with the other to find the two points of silence, in the meantime noting the call letters, tune and points of silence, then figuring the mean



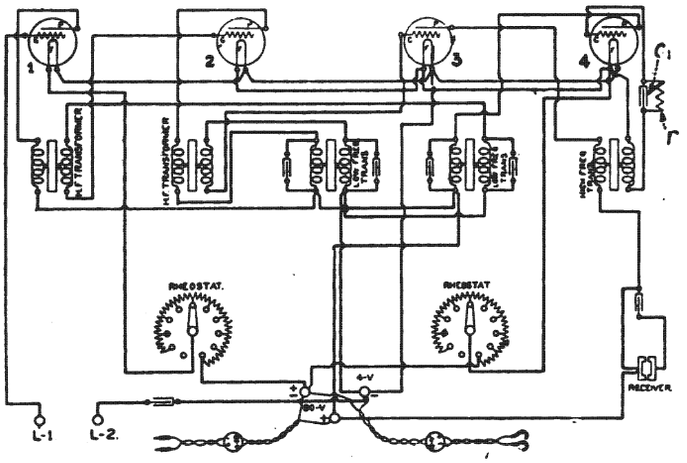
Circuit diagram of Receiver Type No. 2

of these. The wave-length and intensity of signals have to be determined, and whether a message or a call was sent, and in addition a record made of all this data. Two Radio Section men did this at an average of one every two minutes for eight hours!

The first radio goniometric station in the Toul sector having proven so successful, three of these stations were established in July, 1918, along the front taken over by the American Army in the Toul sector. The stations were located at Royaumeix, Cornieville and Saizerais.

Also in July, 1918, three radio goniometric stations were taken over from the French Eighth Army and operated by personnel comprising both French and American soldiers. These stations were located at Tomblaine, Luneville and Brouville.

In anticipation of open warfare, the American 2 kw. automobile tractor radio sets were converted into mobile radio goniometric stations and equipped with Radio Set Type E-3 bis. The first of these tractors proved so useful



Circuit diagram of Amplifier Type L-3

that two more tractors were rebuilt as described. In the St. Mihiel drive they proved of great value. One was stationed at Cornieville, one at Royaumeix, and one at Saizerais. The readings of all stations were transmitted by radio and, as the attack progressed, the Cornieville tractor advanced and took a more forward position at Hattonville. The tractors were afterward sent to the Verdun sector, where they continued their excellent work.

In the latter part of September, 1918, the goniometric stations of the French at Voncourt and Wombey, in the Verdun sector, were taken over from the French. These stations gave good results under American control until the St. Mihiel drive left them stranded, as the operators expressed it—in the "Service of Supplies."

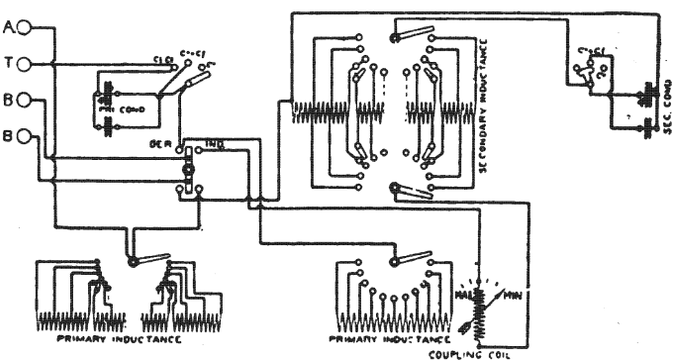
The three radio goniometric tractors moved from the Toul sector to the Verdun sector were stationed at Ville-sur-Taube, Avecourt and Verdun. In co-operation with three French radio goniometric tractors they covered the advancing front extending from the western edge of the Argonne to the right of the First American Army east of Verdun. They were later supplemented by a permanent station at Verdun. Reports from the "gonio tractors" were transmitted by radio to the P. C. T., located at First Army Headquarters, and to the Headquarters of the Second American Army on our right and to the Headquarters of the Fourth French Army on our left. The rapidity of the advance kept the tractors continually on the move, and oftentimes they worked as far as 75 kilometers from their base in the shell-torn and gas drenched territory just back of the fighting line.

The equipment used in both the permanent and tractor radio-goniometric stations was standard French radio equipment for the most part and was identified as follows: Goniometric station, complete, comprised a loop receiver—Type No. 2 or No. 3 Loop Compensator, and Amplifier Type L-3. A portable wooden hut was supplied to house the instruments and provide shelter for the operators.

The apparatus of the goniometric station was connected up in accordance with the accompanying schematic diagram. The hut and equipment served as a semi-permanent station for the reception of radio signals having wave lengths between 250 and 1400 meters, and for simultaneously determining the direction from which they were sent. Two such stations working in conjunction served to locate approximately the sending stations by means of simple triangulation. The loop, which is about ten feet square, is mounted above the roof on the end of a heavy wooden shaft, and can be rotated by means of a hand wheel attached to the shaft inside the hut. The lighter and smaller loops previously described were much easier to rotate.

The loop consisted of three turns of wire and the signals were received in the loop and loop receiver circuit, which was in turn connected to the amplifier that detected the signals. A German transmitting station having been picked up, the loop was rotated until a position was found in which the signals became inaudible; approaching this position alternately from opposite directions, an average position of minimum audibility was found, which gave approximately the direction from which the waves were coming; when the signal was faintest the plane of the loop was known to be perpendicular to the direction from which the signal was coming. If at first no position of complete silence was obtained, the loop compensator was used and successive adjustments of the compensator and plane of the loop were made until complete silence was obtained. An oriented pointer and a dial on the loop shaft indicated the geographic bearings for all positions of the loop.

The Loop Receivers Types No. 2 and 3 comprised only variable condensers, together with either one or two fixed condensers; in the circuit diagram herewith they are illustrated in conjunction with the loop compensator. The loop compensator was used to correct the inequality of the capacities of the two leads to the loop with respect to the ground. The loop compensator is simply an air condenser with three sets of plates, two fixed and one movable. The fixed plates are connected respectively to the two-loop leads through the loop receiver while the movable plate is grounded. It is therefore possible, by rotating the grounded plates, to equalize the capacities of the leads of the loop to a certain extent. This adjust-



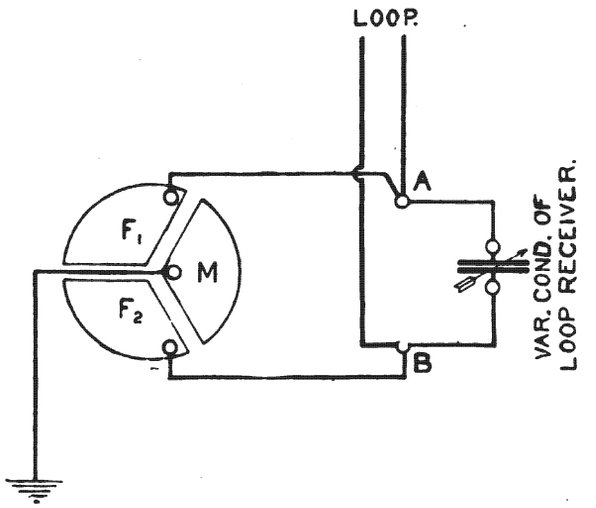
Circuit diagram of Receiver Type No. 3

ment is good for any wave-length, but it is extremely critical with reference to the position of the operator and any masses of metal and other similar effects.

The Amplifier Type L-3 was designed for receiving signals on wave lengths ranging from 200 to 1,000 meters. It makes use of four standard French vacuum tubes, as will be seen from the accompanying circuit diagram. The first three tubes act as high frequency amplifiers. The fourth tube, in which the grid is connected to the positive lead of the filament by means of a conductor, in which is placed a condenser C shunted by a high resistance R, acts as a detector. The low frequency detected

current is again amplified by the second and third tubes.

The first "high frequency" part of the apparatus forms an amplifier with a transformer having thin sheet iron cores. High frequency currents flow through the transformer marked HF. The amplified currents flow through the condensers, shuting the windings of the low frequency transformers, whose impedance is very high for high frequencies, but which permits the flow of the continuous component of the filament-plate current. For currents of audible frequency the capacity of the condensers is greater than the reactance of the transformers. The low-frequency currents therefore flow through the transformer windings and are amplified by the second and third tubes as in an ordinary low-frequency amplifier.



Circuit diagram showing use of loop compensator in radiogoniometric stations

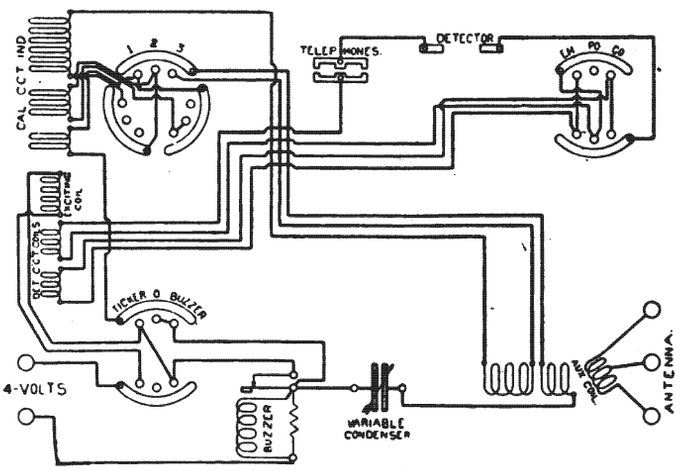
The number of messages sent in "clear" English—uncoded—and other violations of the radio regulations of the A. E. F., demonstrated the need for stations which specialized in copying messages transmitted by American field stations. Two control intercept stations of this character were established at Toul in July, 1918. One station copied damped wave-signals and the other station copied undamped wave-signals. When the First Army Headquarters moved to Souilly, two undamped wave-control stations were put into operation to supervise the work of American operators in that sector; by promptly reporting messages sent in "clear" they on several occasions succeeded in suppressing this dangerous form of radio communication.

At the time that the chain of radio goniometric stations were established along the Toul front airplane radio intercept stations were installed at Royaumeix and Tomblaine. From Royaumeix a special telephone line to Toul was used to send "alerts" to the Air Service, and similar direct connections were provided from Tomblaine to French Air Service pursuit squadrons. The radio goniometric stations generally took bearings only on German field radio stations, but when an enemy airplane was picked up by the special airplane radio intercept station all radio goniometric stations were notified and bearings were immediately taken to determine the position of the Hun plane. This work was unusually successful, and many hostile airplanes, directing their artillery by radio, were interrupted in their mission by the appearance of American pursuit planes which were enabled to fly directly to the approximate location of the German plane. The record of enemy airplane flights, the signals sent, and the portion of the front over which the German planes operated, was of great assistance to the Intelligence Section (General Staff) in compiling their charts of hostile airplane activity.

In the Verdun sector a combined airplane radio intercept and airplane radio goniometric station was able to locate many hostile airplanes, and by means of a special telegraph wire it was possible to immediately give notification of an enemy radio fire control airplane calling its battery. The Intelligence Section (General Staff) was usually able to identify the German artillery battery about to fire and notify the proper counter battery commander. Our artillery was often able to counteract the German artillery fire, sometimes even before it had really started its intense fire.

A press and general radio intercept station was established early in the fall of 1917 at American General Headquarters in Chaumont. This station copied all European press messages and communiques, as well as nearly all commercial and official business transacted between the Central Powers and neutral countries Inasmuch as Nauen (POZ) carried on much suspicious high speed transmission with Spain—ascertained by copying the corrections transmitted by hand of the high-speed message text—plans had been made to install high speed reception apparatus at this station, but the armistice intervened.

This article would not be complete without recording the service rendered by Major Robert Loghry. He was untiring in his efforts and was largely responsible for the excellent results obtained by the Radio Section. Nor would this article be complete unless acknowledgment was made to the French Army for the results obtained by our Radio Section. By furnishing equipment and radio stations and especially by the personal assistance given by the French army radio intelligence officers, the American Radio Section was able to reach a state of high operating efficiency in a short time which otherwise would have been impossible.



Circuit diagram of wave meters—Types Nos. 2 and 3

The fourth instalment of "Wireless in the A. E. F." will appear in an early issue of the Wireless Age.

Wireless in the A. E. F.

First Authentic Account of the Organization of the Radio Division of the Signal Corps and an inside View of the Great Obstacles Which Americans Had to Overcome

By Lieut. Col. L. R. Krumm
Officer in Charge of Radio Division, Signal Corps, A. E. F.

and Capt. Willis H. Taylor, Jr.
Co-ordination Officer, Radio Division, Signal Corps, A. E. F.

Part IV—Listening Stations

LISTENING stations were a development of trench warfare, so it naturally followed that the credit for the first utilization of the sensitive low frequency vacuum tube in connection with grounded antenna covering a considerable area was variously claimed by the different armies engaged in the war before our entry. Documents published by the Intelligence Service of the British Army indicated that the German army used their stations against them at the first battle of the Marne. Certain it is, that at the end of the war, the Germans were as well informed regarding listening stations as were the Allies.

This listening station was located in a Vosges mountain sector and was operated jointly by the French and Americans

The information regarding German listening stations published by the British Intelligence Service consisted of captured orders and other data indicating that at the beginning the Germans realized that the effectiveness of listening stations was unlimited, if knowledge of their existence and efficiency could be kept from the enemy. They took extraordinary precautions to keep from their own men—other than those actively engaged in the operation of the stations—knowledge of the existence of these stations. This was the reason why their soldiers, when taken prisoners, could give no hint to the Allies during the usual gruelling cross examination. All the information obtainable indicated that the operators were especially selected and trained for this duty, this personnel being entirely segregated from other troops and special arrangements made for their subsistence and maintenance, making it unnecessary, and in fact, almost impossible, for them to come into contact with the general body of the combat units.

Stories were current of the early days of trench warfare, when in many places the front line trenches were separated by a strip of No Man's Land only fifty yards wide and the necessity for the telephone code was not appreciated, that many an attack came to naught because of information intercepted from telephone lines of both sides by these listening stations. Later, when their use became general in all the armies, the Germans were evidently so impressed by the effectiveness of their own stations that they greatly restricted the use of the telephone in their front lines. The instruments were sealed and their use limited to absolute emergencies; an explanation was required from the breaker of the seal as to the necessity for usage of the telephone.

The interception of T. P. S. messages naturally could not be prevented, and, as with radio, the use of code was compulsory, but even here the Germans attempted to prevent the effective use of our listening stations by employing interfering screens of audio-frequency ground currents, as will be explained later.

Toward the end of the trench warfare operations, listening stations lost a considerable part of their effectiveness because of the general knowledge of their use by all the armies. Possibly the greatest factor in limiting the results obtained by the enemy listening stations in interception of conversations on our lines, however, was the radio section listening stations which acted as monitors of our own circuits. A well insulated and balanced metallic telephone circuit is practically immune against eavesdropping, but such lines were difficult to maintain in quiet sectors and practically impossible in active sectors. Faulty conditions on our own lines were therefore immediately revealed through our listening stations, as well as the transmission of indiscreet messages over leaky or grounded telephone lines. As a result, our telephone circuits were maintained in the best possible condition through the operation of our listening stations against them as well as against those of the enemy. Many an infantry officer reading this article will realize for the first time the source of information upon which was based the reprimand he received for the transmission of an important message in plain English over a telephone.

The use of the listening station was continued in our army up to the last, even in mobile warfare, although conditions were generally unfavorable. The fact that the hastily rearranged and reconstructed telephone lines of the enemy were increasingly defective, compensated somewhat for the difficulties encountered in the operation and maintenance of our stations.

Prior to the development of the listening station, adventurous men in the Allied armies had endeavored to ascertain the enemies' plans by direct tapping of their telephone lines, signalmen crawling across No Man's Land on dark nights to bridge a telephone on the enemies' circuits. But even the advent of the listening station did little to lessen the hazards, and no activity of the Radio Section of the Signal Corps, A. E. F., was more thrilling—and more interesting—than the listening station service.

The radio intercept and radio goniometer service which

has been previously described was probably the source of more information, but these stations were usually placed from five to ten kilometers back of the line, in locations of comparative safety. In quiet sectors, and during the first months of our army's operations in France, this class of stations took on to some extent the humdrum character of a commercial receiving station. But the listening stations located in dugouts in or near the front trenches were never without excitement, nor were the personnel assigned to them permitted by the enemy to forget that they were actively participating in a war.

While the function of the stations and the duties of the operators were limited in possibilities, life in a listening station never became monotonous or lost its fascination. Thus the listening service became the goal of every member of the Radio Section who craved action and adventure. However, the qualifications necessary for service in listening stations were more than ordinarily diversified. The first essential was a thorough familiarity with the German language. The operators were given a course of training to familiarize them with the military phrases they might be expected to overhear, but fundamental knowledge of German was a necessity; time did not permit the teaching of the language, and a superficial knowledge was not sufficient. Most of the men selected were of German descent and accustomed to speaking the enemy language previous to entering the army.

Our first effort to obtain suitable men took the form of a request for the Signal Corps in the United States to send over all the German-speaking radio operators available. Inasmuch as the first detachment of 40 German-speaking radio operators, which arrived about the beginning of January, 1918, apparently exhausted the supply, it was decided to make no further efforts in this direction. It was found that the ability to receive and record T. P. S. (ground telegraph) messages was secondary to the necessity of knowing German thoroughly, as T. P. S. code was sent slowly, usually not exceeding the rate of 10 or 12 words a minute. All efforts were, therefore, directed to obtain personnel by selecting men already in the A. E. F. having a knowledge of German and teaching them the T. P. S. code.

Our efforts to obtain such men from the different line organizations in the A. E. F. were productive of many laughable results. Evidently the commanding officers of many units assumed that if a man spoke any foreign language it must be German, and with the numerous nationalities represented in our army the possibilities in selection are evident. Many also reported with only a smattering of German and were promptly returned to their outfits, except for a chosen few whose cooking ability was utilized in place of alleged philological accomplishments.

The selection of German-speaking soldiers also had its less humorous side. When the first detachment of operators arrived from the United States, the men themselves had no definite idea of their prospective duties. An intelligence officer was detailed to ascertain the extent of the linguistic ability of each member, and few made any effort, for they were fearful that signs of ability coupled with German names might be prejudicial to their interests. Only after it was explained that they were intended for a duty of a particularly valuable nature did they loosen up; even then some of them did not disclose their true fluency.

Special commendation is due the men in this service for their great devotion to their duties. Above all, a listening station operator had to be observing, possess imagination and be able to visualize the possibilities within snatches of enemy conversation that came to his ears, and he had to do it quickly if his intuition was to be of any value. We were fortunate in having in our service many men possessing all the qualifications, perhaps the best of whom were those who had been newspaper reporters before the war.

Proper conception of the operation of a listening station requires an understanding of the elementary electrical phenomena which it makes use of, principles which are the same as those used in the T. P. S. (ground telegraphy) operations. Figure 1 shows a T. P. S. buzzer transmitter with its ground connections at the end of wires of approximately 100 meters length. The transmitter is an induction coil taking about 5 amperes at 10 volts in the primary, and generating in the secondary coil a high voltage alternating current of audible frequency. The secondary coil is connected direct to the grounds, the lines of current flow between which are indicated by the dotted lines in figure 1. The equipotential lines (shown in full lines in the figure) are perpendicular to the lines of current flow. If two earth connections are made at points such as 4 and 6, which are not on the same equipotential line, and if the wires leading to the earth connections are connected to a pair of telephone receivers, a current will

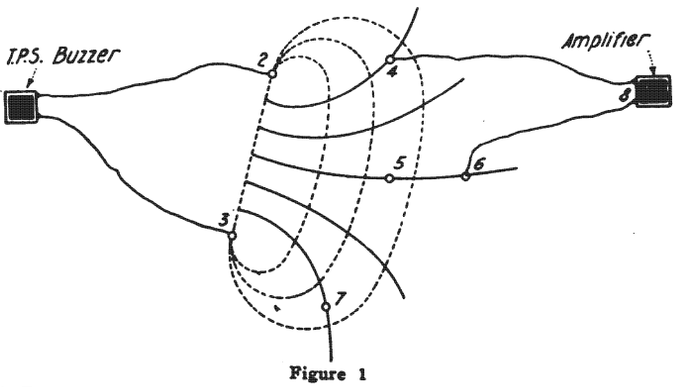


Figure 1

A T. P. S. buzzer transmitter with its ground connections at the end of wires of approximately 100 meters length

pass through the 'phones. If the current is of sufficient strength, the T. P. S. buzzer signals will be heard. If the current is weak—and it usually is—it is necessary to insert an amplifier in the wires leading to the earth connections. It was for this purpose that the vacuum tube amplifier came into use. The amplifier with the two wires and the earth connections—or "earthed antenna," as they are called—make up the essentials of a listening station. If, instead of the two earths 4 and 6, which are situated on two different equipotential lines, two earths, 5 and 6, on the same equipotential line are chosen, no current will flow and, therefore, the buzzer signals will not be heard by the listening station. For similar reasons two earths, such as 4 and 7, which are at a greater difference of potential than the earths 4 and 6, give stronger signals than the earths 4 and 6.

There is also another and lesser effect to be considered, the effect of induction. The circuit 1, 2, 3, is a closed circuit, the earth closing the circuit between 2 and 3. Similarly, 4, 6, 8, is a closed circuit. Therefore, the buzzer loop affects the amplifier loop to some extent by electromagnetic induction. Leaving out of consideration the question of phase difference, the inductive effect adds to the difference of potential effect, discussed in the preceding paragraph. In general, in a system such as shown in Figure 1, the inductive effect is much smaller than the difference of potential effect. Other effects such as the direct inductive and capacity reactions between the earthed antenna of the buzzer circuit and those of the amplifier circuit, etc., may be disregarded, because of their relatively small importance in comparison to the first two effects.

A grounded telephone system used as the source of signals may be considered in exactly the same way as has been done for the T. P. S. buzzer set; there is no difference between the two cases.

An insulated telephone system presents a slightly different case. This system influences the receiving station only by induction. This it does in two ways: first, by direct inductive action on the loop of the receiving station; and second, indirectly, by inducing earth currents which are then picked up by the earths of the receiving station. If the line wires of a well insulated metallic telephone circuit are twisted together, the resultant stray field is feeble, and hence any inductive effect is small. It is practically impossible to overhear signals on such a system.

If the two earthed antenna of the listening station (Figure 1) are entirely insulated from the ground, and if the ends, 4 and 6, are connected by a wire also insulated from the ground, we then have, instead of the earthed antenna, an insulated loop, and the station receives signals by induction only. The insulated loop system was used to some extent by the French.

Listening stations are a development of trench warfare and no activity of the Radio section was more thrilling and more interesting

A listening loop utilizes inductive principles only, and its main advantages over the grounded antenna—in which it is very similar to the radio loop—is its comparative freedom from ground static. Loops were not used extensively by us, because of the difficulties of properly maintaining and repairing them. Loops installed in trenches are too liable to injury, so we placed our reliance in grounded antenna. Several turns in the loop are necessary to obtain satisfactory results and this naturally adds to the maintenance difficulties.

It must be remembered that these listening stations can be used only where conditions are favorable and when the opposing armies are fairly close together, as in trench warfare; and also when the intervening conditions of the terrain are such as will not shunt or side-track the currents which it is desired to intercept. An intervening river or gully or metallic geological formation was found to prevent successful operation in many places.

It was necessary to get the ground plates as close to the enemy as possible, and their installation required the highest type of bravery in the men who accomplished it. The personnel operating listening stations were continuously on duty one week, then off one week, which kept them in the front lines considerably longer than was required of the infantry under ordinary conditions.

The dugouts in which the stations were located were usually a few hundred meters from the front line, and generally in the support or communication trenches; but some times they were concealed under the ruins of a demolished house or structure. One of the first stations established in the Toul Sector, where most of our troops of all services obtained their first taste of real war, was in the village of Marvoisin at the foot of the ever menacing Mt. Sec. The dugout was located under the ruins of an old stone church which had been demolished by shell fire, but it was seen that these ruins formed a fine protection for the station when an enemy shell made a direct hit, but did not penetrate into the dugout proper. The force of the concussion demolished the amplifier and threw the operator on duty off his comfortable seat; it also greatly enhanced his respect for churches.

From the dugouts the leads followed the trenches to their terminating grounds, located at intervals of several hundred meters along the front line trenches and close to the enemy lines as possible. These grounds consisted of copper mesh mats about two by ten feet, buried a few feet under ground. If it was impractical to thus install them, a group of metal stakes were driven down.

Because of the large area covered by the ground antenna these stations were more effective in receiving T. P. S. messages than the regular T. P. S. receiving stations in which grounds were usually separated by approximately 100 meters. Nearby radio stations could also be heard when the French amplifier was used, a combination apparatus providing for the rectification and amplification of radio signals in one position of its control switch, and low frequency amplifications with all three tubes, with the other position. Even when so used, it was found that radio signals could be heard in it. Investigation developed that the first low frequency transformer connected to the ground antenna showed a capacity reactance to radio frequency currents due to its distributed capacity. The inductive effects of this radio frequency current on the remainder of the amplifier wiring evidently resulted in the unintentional detection of radio stations and a demonstration of grounded radio antenna possibilities.

Because it was possible for the listening station to select different grounds, an idea of the approximate direction and distance of a transmitting station might be obtained by an operator of long experience. T. P. S. messages could be heard for as much as 4 kilometers and telephone conversations 2 kilometers. This distance of course depended on the degree of grounding of the telephone lines. The listening station shown in the accompanying photograph does not by any means represent a typical one. It will be observed that it has been located in the same place for a considerable period. This station was located in a Vosges mountain sector on the extreme right of our Toul Sector and was operated jointly by the French and ourselves. The quietness of this sector is attested by the neatness and the apparent comparative comfort.

From the station dugouts the insulated leads radiated to the grounds, which were from 500 to 1500 meters away, and distributed along the front line trenches at intervals of from 200 to 300 meters. They were often carried well over toward the enemies' trenches, for the effectiveness of the station was dependent on the distance to the source of the intercepted current, as will be appreciated from the foregoing explanation. Grounds were also installed in our own area back of the station for use when it was used as a monitor for our lines. Because of the proximity of listening stations in this work it was much easier to overhear the communication within our lines, and by the same token this drowned out much of the German communication we were trying to copy. Listening stations have more interference to contend with than a radio station, because the element of tuning is not available and because of so-called "earth static."

The principles used in listening stations are well known and have long been utilized, but only with the development of the super-sensitive vacuum tube amplifier did their possibilities become valuable for war purposes. The type 3 ter French amplifier first utilized has already been

described. Later the type SCR-72 amplifier was received from the United States, and was found to be a trifle more efficient for voice and audible frequency currents. The circuit for this amplifier is the usual audio frequency amplifier utilizing two tubes as against three in the French amplifier, but it was only intended for low frequency amplification and no provision was made for rectifying radio frequency currents as in the French instrument.

Many times it seemed that the Germans were providing an electrical screen for their communication, for their motor noises came in so loud in some cases that we believed they had intentionally carried over wires from their machine and grounded them near or in our lines so as to drown out the signals from their T. P. S. stations further back. However, it was noticed that if these motor noises stopped there was an immediate increase in the T. P. S. activities so that if it was a purposely provided screen it would have also been effective in interfering with their own ground telegraphy. No doubt it was effective in protecting their defective telephone lines.

That the operators determined the efficiency of our listening service, however, is a fact that must not be lost sight of. This service could not be organized as scientifically as the radio intercept stations, in which gonio stations could locate the radio stations intercepted and wave lengths could be measured and other characteristics of the stations recorded. The listening station operator had only his ear to aid him in determining the probable distance and location of the station he overheard. T. P. S., like radio, has characteristic notes and the operator's "fist" also betrays itself, but neither of these are as pronounced as in wireless.

The listener had therefore to depend on his judgment to determine what any unusual occurrence or activity might foretell, in addition to what might be revealed by the decoding of the message he recorded. He soon learned that unusual T. P. S. activities by the enemy forecasted a military offensive or some unusual operation. For weeks his efforts might be unproductive, but his vigilance could not be relaxed. A probable change in an enemy station could be noted by a change in its note or in its intensity. A sudden change in the T. P. S. communications indicated a difference in the troops opposite or a rearrangement of their lines. The first information regarding the relief of enemy battalions opposite was usually obtained through our listening station operators noting the change in their T. P. S.; in nearly every case the operator's deduction would be later verified by a prisoner.

By diagramming the T. P. S. stations of the enemy according to loudness and the stations with which they worked, operators could quite accurately place the large and small units, their observation posts and posts of command. Just previous to the St. Mihiel operations, the operators quite accurately reported the withdrawal to the rear of the enemy T. P. S., which indicated the removal of troops from the front lines, or at least a rearrangement of the forces.

The listeners were repeatedly commended by the General Staff for their intelligent deductions, especially with regard to telephone interceptions. In this work—which could not be recorded literally—the operator had to act as an intelligence officer. One man deduced the arrival of a new division opposite him by the increased politeness used in telephone communication, and he proved to be right in his surmise. As the Germans also used code words for all places and military phrases in their telephone conversation, only the slightest clues were available for making deductions. Through hearing a certain time spoken repeatedly by the enemy and its anxious reception at the other end of the lines, the 42nd Division was warned of attacks on Ferme-le-Chamois, Village Negre and La Chapellette, and being forewarned they effectively repulsed the offensive.

The most hazardous part of the operation of the listening station was in the maintenance and installation of the ground lines. The entire effectiveness of the station obviously depended on the maintenance of the lines in good condition; they were continually broken by artillery fire and the necessity for repairs was always immediate.

It was at these lines that the fibre of the station personnel showed at its best. Usually wearing their gas masks, the men stuck to the task, in most cases under shell fire, until they had established their circuits. In one instance

Facsimile of German poster distributed amongst the German Intelligence Service for the purpose of retaining secrecy

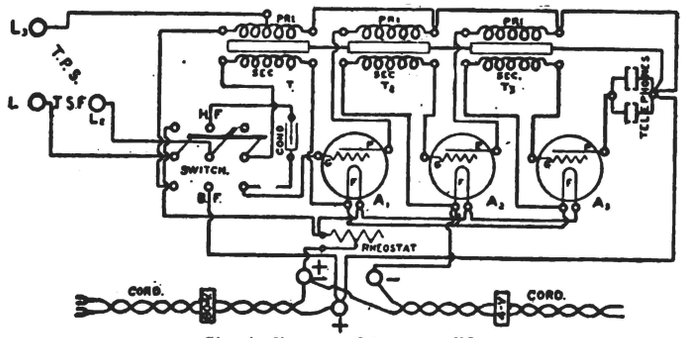
all three operators of the station were wounded during an attack on our position. The majority of casualties in the Radio Section occurred in this service, and there is not one case of a man shirking his duty. If a station was not getting satisfactory results it was usually the operators who suggested the advisability of carrying the grounds over nearer the German lines, then they would volunteer to install it themselves.

These night excursions to bury ground mats in the enemy area showed our men's intense interest and devotion to their work. At these times they were usually accompanied by a covering patrol and it took many hours of slow arduous crawling through barbed wire entanglements and across No Man's Land to carry the wire to the desired location. Then followed the stealthy burying of the mat to accomplish the desired end. Star shells threatened to reveal their presence every few minutes and they could advance only during the intervening periods. Returning, they might be taken for an enemy raiding party by some nervous doughboy and be received accordingly. This actually occurred more than once.

The Seicheprey fight was waged all around one of the listening stations and for a time it was behind the German front. Fortunately, in the night and the confusion its ex-

istence was not realized by them and when American counter-attack recovered the ground the operators were still on the job.

Another factor that increased the effectiveness of listening stations was the possibility of connecting on to old and grounded lines running over into enemy territory. In the continual surging back and forth of their fronts both armies necessarily abandoned lines in areas which later came under enemy control. The trenches were a mass of old and abandoned wires of both sides and these were usually the bane of the telephone men of our Signal Corps in taking over sectors from the French. Their greatest ambition seemed to be to tear them all out and start over with new and better circuits, thus in many cases they de-



Circuit diagram of 3-ter amplifier

stroyed a source of information for us. In one case the allied armies were notified of a commercial underground cable, installed before the war, but lying behind both lines; this cable possibly would have been a fertile source of information to the army that could connect to it without the other's knowledge. Some of these old circuits that extended far back into our lines were certainly the source of information to the enemy, as there were reported many incidents, such as the shelling of expected relief troops or truck trains in the night, which could only have been ascertained by intercepting telephone conversations, possibly only a few minutes before the expected arrival. A typical instance was that of a Brigade headquarters which received its supply trucks every night at a regular hour, and as regularly the road was shelled. It was assumed the Germans had in some manner ascertained this hour and it was decided to change it. Arrangements were made over the line and, sure enough, the time of shelling changed also. Inasmuch as the headquarters was too far back for an ordinary listening station to be effective, it is probable that the Germans had connected to an old line running back over the intervening five or six kilometers.

One of the most daring feats in the listening service was that performed by Private 1st Class George Stroh, who volunteered to accompany a raid on the German position at Marcheville, and install a ground connection for his station inside the enemy line. He went along with the attacking party carrying his wire ground stakes and tools, and when the infantry had attained its objective he coolly proceeded to hammer in his stakes and lay his wire as he returned to his listening station in Soule.

Sergeant Carleton R. McQuown, while installing a ground at night near the enemy lines, discovered a machine gun nest, and the following night an American raiding party acting on his information succeeded in destroying it and capturing twenty-eight prisoners.

Incidents like these, indicating the bravery and resourcefulness of the listening station operators, were so numerous that only a few can be mentioned. It has repeatedly been said that the glamor has gone from war, but the experiences of these men, who in the new warfare combine somewhat the duties of both the scout and the spy give this assumption the lie. Among the men cited for their work by the General Staff were Corporal (later Lieutenant) Frank B. Fairbanks, Sergeant Braun, Corporals Floyd F. Felmick, L. V. Garner and H. T. Schoefer, and Privates 1st Class L. V. Pease, D. O. Butterfield, W. R. Hogel and Geo. J. Baum.

If anyone could be expected to be "fed up" on war, listening station operators certainly qualified. These men, in many cases for nearly half their term of service in France, had for their quarters dugouts the size of a packing case, with smelly pools rising in the bottom and rats and smaller but no less active intruders as constant companions. Under these conditions they worked, ate and slept—certainly they can claim to have done their bit for their country.

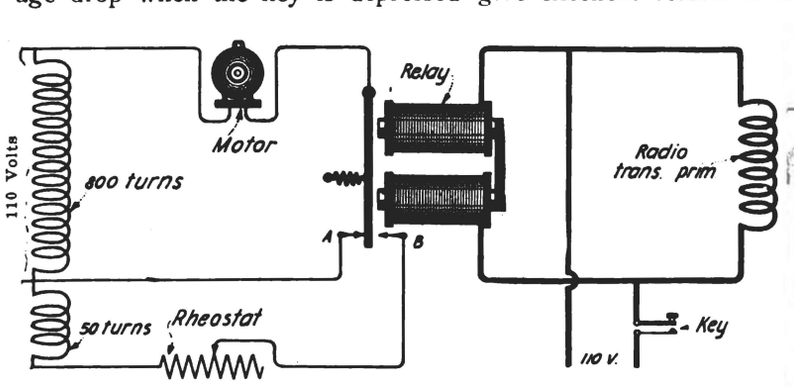
Constant-Speed Regulator for Series Motors

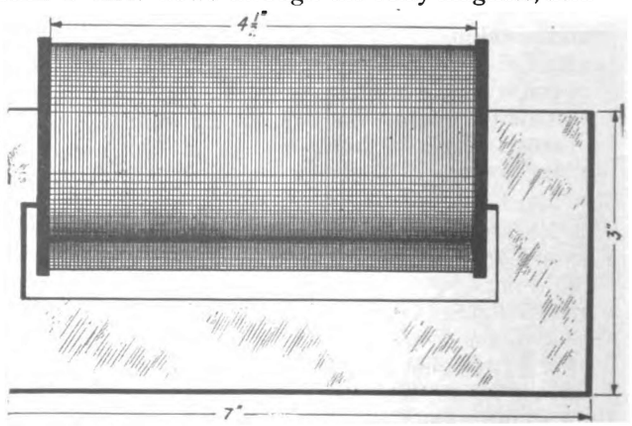
By L. A. Bartholomew

IN many amateur stations where a series motor is used for the rotary spark gap, in connection with a transformer of considerable input, the voltage drop when the key is depressed is sufficient to slow down the motor somewhat resulting in a disagreeable "whine" in the spark note. Sometimes this can be remedied by increasing the size of the wiring in the station, but more often it is due to insufficient capacity of the power company's feeders which is beyond the control of the consumer.

A method which has been found to give excellent results in such a case, and which may be of value to other amateurs troubled in the same way, is to insert a small auto-transformer in the motor leads with a double contact relay connected to the key. Figure 1 shows the circuit for such a device. When the key is open, the regular line voltage flows into the motor through the contacts A. As soon as the key is pressed, however, current also flows through the relay magnets, actuating armature and closing contacts B, which connects the motor across the entire winding of the auto-transformer, and the increase in voltage will compensate for the drop due to the

(*Continued on page 22*)





Circuit diagram and dimensions of coil