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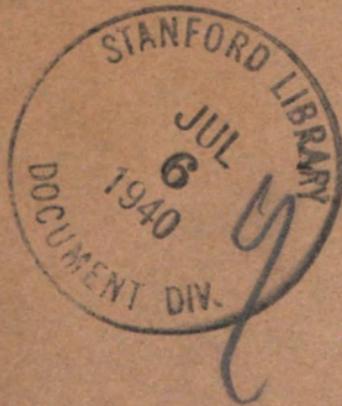
FM 11-5

WAR DEPARTMENT

SIGNAL CORPS  
FIELD MANUAL



MISSION, FUNCTIONS, AND  
SIGNAL COMMUNICATION  
IN GENERAL





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FIELD MANUAL**



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IN GENERAL**

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Prepared under direction of the  
Chief Signal Officer



UNITED STATES  
GOVERNMENT PRINTING OFFICE  
WASHINGTON: 1940

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**WAR DEPARTMENT,**  
**WASHINGTON, April 15, 1940.**

**FM 11-5, Signal Corps Field Manual, Mission, Functions,  
and Signal Communication in General, is published for the  
information and guidance of all concerned.**

**[A. G. 062.11 (12-8-39).]**

**BY ORDER OF THE SECRETARY OF WAR:**

**G. C. MARSHALL,**  
*Chief of Staff.*

**OFFICIAL:**

**E. S. ADAMS,**  
*Major General,*  
*The Adjutant General.*

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## SIGNAL CORPS FIELD MANUAL

### MISSION, FUNCTIONS, AND SIGNAL COMMUNICATION IN GENERAL

(The matter contained herein supersedes ch. 1; sec. I, ch. 5; ch. 6; and ch. 7, SCFM, vol. I, November 20, 1931; and SCFM, vol. II, December 10, 1931.)

#### CHAPTER 1

##### PURPOSE OF MANUAL AND REFERENCES

■ 1. **PURPOSE.**—The 11-series of field manuals contains the approved doctrines governing the training and employment of the Signal Corps which are not included in FM 24-5. These Signal Corps Field Manuals are based upon the Field Service Regulations and the Staff Officers' Field Manual and include the following:

*a.* FM 11-5, Mission, Functions, and Signal Communication in General.

*b.* FM 11-10, Organization and Operations in the Infantry Division.

*c.* FM 11-15, Organizations and Operations in the Cavalry Division and Cavalry Corps.

*d.* FM 11-20, Organizations and Operations in the Corps, Army, and Theater of Operations.

■ 2. **REFERENCES.**—*a.* For a list of principal War Department publications relating to signal communication, see FM 24-5.

*b.* For a complete list of War Department training publications, see FM 21-6.

## CHAPTER 2

### MISSION

■ 3. **GENERAL.**—The Signal Corps is a service as well as an arm and has the following missions (AR 105-5) :

*a.* The development, procurement, storage, issue, and repair of signal, meteorological, and cryptographic equipment and supplies.

*b.* The development, procurement, storage, and issue of all electrical apparatus associated with direction finding for determining the location of radio stations, aircraft, and marine craft, and of all the electrical apparatus associated with range finding.

*c.* The procurement, storage, and issue of photographic supplies and equipment except that required for—

(1) Photographic and cinematographic work made from aircraft.

(2) Ground photography in connection with aircraft operation and maintenance.

(3) Other special purposes for which the procurement, storage, and issue of photographic supplies and equipment have been specifically charged by the War Department to another arm or service.

*d.* The preparation and revision of all books, pamphlets, and instruction data required by the Army to make proper use of all equipment and apparatus developed, procured, and issued by the Signal Corps.

*e.* The preparation, publication, revision, storage, accounting for, and distribution of all codes and ciphers required by the Army, and in time of war the interception of enemy radio and wire traffic, the location of enemy radio stations, the solution of intercepted enemy code and cipher messages, and laboratory arrangements for the employment and detection of secret inks.

*f.* The installation, maintenance, and operation of all military signal communication systems and equipment, including

military cable, telephone, and telegraph lines, radio apparatus and stations, except the routine maintenance and operation of fixed fire-control communication systems and fixed airways and airdrome control systems and radio aids to air navigation (see par. 7a (1)), and the installation, maintenance, and operation of signal communication systems used by combat troops in field operations as provided in paragraph 7a (2), over which it will exercise general supervision only.

*g.* The transmission of messages for the Army by telegraph or otherwise.

*h.* The coordination of the training of the personnel assigned to signal duties, under such instructions as may be prescribed in orders from the War Department.

*i.* The general supervision, coordination, and standardization of all radio operations and the enforcement of regulations concerning the same.

*j.* The assignment of call letters, radio frequencies, power, type of emissions, and schedules for all Army radio stations.

*k.* The procurement and supply of photographs and motion pictures directed by the General Staff, and in general all photographic and cinematographic work of the Army not specifically assigned to other arms or services.

*l.* The assignment of designation numbers to all Army submarine communication cables and the keeping of records thereof.

*m.* The performance of all other duties usually pertaining to military signal communication other than as provided for above.

■ 4. ELIGIBILITY FOR OTHER DUTY.—Detachments or units of the Signal Corps will be exempt from detail for any other duty, outside their organization work and training, except when in the judgment of the commanding officer the importance of the duty will not permit exemption.

■ 5. SEPARATION OF FUNCTIONS.—In order to accomplish the missions given in paragraph 3, the Signal Corps has training, supply, photographic, signal intelligence service, and signal communication functions. Chapters 4 to 8, inclusive, cover these functions in the field. In the corps, cavalry corps, and division, the supply and signal intelligence service func-

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*d.* The preparation and revision of all books, pamphlets, and instruction data required by the Army to make proper use of all equipment and apparatus developed, procured, and issued by the Signal Corps.

*e.* The preparation, publication, revision, storage, accounting for, and distribution of all codes and ciphers required by the Army, and in time of war the interception of enemy radio and wire traffic, the location of enemy radio stations, the solution of intercepted enemy code and cipher messages, and laboratory arrangements for the employment and detection of secret inks.

*f.* The installation, maintenance, and operation of all military signal communication systems and equipment, including

military cable, telephone, and telegraph lines, radio apparatus and stations, except the routine maintenance and operation of fixed fire-control communication systems and fixed airways and airdrome control systems and radio aids to air navigation (see par. 7a (1)), and the installation, maintenance, and operation of signal communication systems used by combat troops in field operations as provided in paragraph 7a (2), over which it will exercise general supervision only.

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*j.* The assignment of call letters, radio frequencies, power, type of emissions, and schedules for all Army radio stations.

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tions are so closely related to signal communication that they are included in the latter.

■ 6. RELATION TO THE NAVY.—From the standpoint of field operations, a major relationship existing between the Signal Corps and the Navy is that connected with the missions mentioned in paragraph 3*i* and *j*. The Joint Army and Navy Radiotelegraph and Radiotelephone Procedure (JANP) is largely the result of this relationship. Other publications cover signal communication between the Army and the Navy in various operations. Cooperation between the Signal Corps and Marine Corps is also obtained in the standardization of field signal equipment, its installation and operation, and in the training of personnel.

■ 7. RELATION TO OTHER ARMS AND SERVICES.—*a. As an arm.*—As an arm, the Signal Corps bears a close relationship to other arms in—

(1) The operation and routine maintenance of fixed fire-control communication systems by the Coast Artillery Corps, and the operation and routine maintenance of fixed airways control and airdrome control systems and radio aids to navigation by the Air Corps. (See AR 105-20 and 95-200.)

(2) The installation, maintenance, and operation of signal communication systems used in field operations by brigades (except cavalry mechanized brigades) and lower units of all other arms, and the operation of wire circuits for train dispatching and for the administration of military railways by the Corps of Engineers. (See AR 105-15 and sec. II, ch. 8, of this manual.)

(3) The training of selected officers and specialists of other arms within prescribed limits, and the preparation of training literature to accomplish the missions indicated in paragraph 3*d* and *h*.

*b. As a service.*—As a service, the Signal Corps bears a close relationship to all other arms and services in—

(1) The supply to them of signal supplies and equipment.

(2) The production and distribution of photographs, all training films, and codes and ciphers.

■ 8. ORGANIZATION AND AGENCIES IN THE ZONE OF THE INTERIOR.—The following organizations and agencies of the Signal

Corps operate in the zone of the interior in support of organizations in the theater of operations:

- a.* Office of the Chief Signal Officer.
- b.* The Signal Corps Board.
- c.* The Signal Corps and signal intelligence schools.
- d.* The Signal Corps, aircraft radio, and photographic laboratories.
- e.* The Signal Corps procurement districts, depots, and signal sections of general depots.
- f.* The Signal Corps pigeon breeding and training center.
- g.* The Signal Corps repair and maintenance sections.
- h.* Training film production service.
- i.* Signal service companies.
- j.* The Alaska Communication System.

## CHAPTER 3

### SIGNAL OFFICER

■ 9. **COMMAND AND STAFF.**—*a.* For complete information on this subject see FM 100-5 and 101-5.

*b.* The staff assists the commander in the exercise of his command functions. In divisions and larger units the staff may be divided into the general staff and the special staff. For operations in the field a staff is usually organized into forward and rear echelons, the forward echelon accompanying the commander. (See sec. III, ch. 8.)

(1) The *general staff* is a closely coordinated group of assistants to the commander, organized so as to comprehend the essential functions of command. The bulk of the general staff is usually found in the forward echelon.

(2) The *special staff* includes those officers of the various arms and services who may be assigned to a headquarters for technical, supply, and administrative purposes. These officers are organized into sections or services which bear the names of their respective arms and services and which are headed by the senior special staff officer in each. (See par. 12.) For example, the signal section, corps headquarters, is headed by the corps signal officer, and the army signal service is headed by the army signal officer.

(*a*) A chief signal officer is detailed for every expeditionary force. A Signal Corps officer is normally detailed as unit signal officer for each corps area and for every tactical unit larger than a brigade containing Signal Corps troops. When no unit signal officer has been so detailed in orders, the senior Signal Corps officer present for duty with the command acts as such. (AR 105-5.)

(*b*) The signal officer is a technical specialist provided as a member of the special staff for the purpose of assisting the commander in exercising his command functions. In addition thereto, the signal officer commands all Signal Corps troops assigned to serve his headquarters, except that when

such troops are organized as a part of the special troops of that headquarters he commands them insofar as relates to training and employment only.

(c) These two functions of staff and command, although vested in a single individual, are separate and distinct in that each involves different responsibilities and duties, and the exercise of one should not be confused or permitted to interfere with the exercise of the other. On the contrary, this dual function of the signal officer has many advantages in facilitating the proper discharge of both his staff and command duties.

■ 10. DUTIES AND AUTHORITY AS STAFF OFFICER.—As a staff officer the duties and authority of the signal officer are as follows (AR 105-5):

*a. Duties.*—(1) Adviser to the commander and the staff on signal matters, including the location of command posts.

(2) Preparation of routine and combat orders relating to signal communication, including signal operation instructions and signal annexes.

(3) The preparation, publication, storage, accounting for, and distribution of codes and ciphers.

(4) Supply of signal equipment and supplies.

(5) Procurement and operation of signal maintenance and repair facilities.

(6) Technical inspection of signal equipment, within limits prescribed by the commander, and recommendations relative to its care and utilization.

(7) Technical supervision, within limits prescribed by the commander, of all signal operations of the command, including training, assignment, replacement, and utilization of signal and communication personnel of units.

(8) Supervision of the installation, maintenance, and operation of the signal system, including the message center of the unit.

(9) Supervision of such activities pertaining to the signal intelligence, pigeon, and photographic services as affect the unit.

(10) Insuring that the instructions of the Chief Signal Officer relative to keeping technical records and the rendition

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(4) Supply of signal equipment and supplies.

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(6) Technical inspection of signal equipment, within limits prescribed by the commander, and recommendations relative to its care and utilization.

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(8) Supervision of the installation, maintenance, and operation of the signal system, including the message center of the unit.

(9) Supervision of such activities pertaining to the signal intelligence, pigeon, and photographic services as affect the unit.

(10) Insuring that the instructions of the Chief Signal Officer relative to keeping technical records and the rendition

of technical reports are observed by all signal corps officers of the command. (See AR 105-45.)

*b. Authority.*—(1) All orders and instructions from a higher to a subordinate unit are given to the commander thereof, and all orders and instructions for any element or elements of a subordinate unit emanate from the immediate commander of such unit. The signal officer as a *special staff officer* has no authority to command. All policies, basic decisions, and plans, whether originating with the commander or with his staff, must be authorized by the commander before they are put into effect. When the commander has decided upon a plan or policy, it is the duty of the general staff to prepare and issue the orders necessary to provide for its execution and to follow up to insure its execution. When it becomes necessary, and only when specifically authorized by the commander or pursuant to routine established policies, the signal officer may issue an order in the name of the commander. In all such cases, responsibility for such an order remains with the commander even though he may not have seen the order as actually written or heard it as actually issued if given orally.

(2) The staff functions of the signal officer are mainly advisory in nature to the commander and his staff. He is normally given authority by the commander, however, to make such technical inspections in subordinate units and call for such technical reports from similar special staff officers of subordinate units as are necessary in supervising the execution of the work with which he is charged.

(3) In order to obtain information for the commander as to the situation or condition of the signal system, including signal equipment and signal supplies, or to observe the execution of orders or instructions previously issued, the signal officer should frequently visit subordinate units. Such visits are made in the name of the commander as his representative. When making such a visit, the signal officer conducts himself so as to promote cordial relations and cooperation between the staff and the troops. He first calls on the commander of the unit concerned, informs him of the purpose of the visit, requests such assistance as is necessary, and, before leaving, reports to the unit commander such facts

as have been noted. He carefully avoids criticism or unauthorized interference with the responsibilities of the subordinate commander. If it appears that the superior commander's wishes have been misunderstood, the signal officer furnishes the subordinate commander such additional information as is necessary, or in any other legitimate way does his utmost to assist the subordinate commander in comprehending the exact desires of the superior commander in matters pertaining to signal communication.

(4) From the foregoing it becomes apparent that the staff functions of the signal officer embrace matters of both a tactical and a technical nature. Some are clearly of a tactical nature and others are clearly technical, while in certain instances the line of demarkation is not distinct. Since the signal officer is authorized (AR 105-5) to exercise direct technical control, within limits prescribed by the commanding officer, of routine signal matters in subordinate units, there may develop a tendency to group under the technical classification those matters whose classification is questionable. As a staff officer it is incumbent upon the signal officer to promote cordial relations and cooperation, and this can be best accomplished by following the line of action that will be least apt to develop any friction between the subordinate commander and the superior commander or his staff.

■ 11. DUTIES AND AUTHORITY AS COMMANDER OF TROOPS.—a.

As a commander of troops, the signal officer is solely responsible for all matters regarding the Signal Corps troops assigned to serve his headquarters except that he is responsible for the proper training and employment only of all such troops when they are organized as a part of the special troops of that headquarters. The Signal Corps troops assigned to serve a headquarters include attached as well as organic units. Attached Signal Corps units, if any, may be attached to organic units to facilitate administration and discipline. The extent to which all Signal Corps units are commanded by various signal officers is given in the 11 series of field manuals covering the operations of those units.

b. In the exercise of this command duty, the signal officer functions in a capacity comparable to that of a battalion or regimental commander in relation to his subordinate units,

being careful that if he is not the commander under Tables of Organization he does not usurp the prerogatives of the unit commanders of the organic and attached units. The specific duties of the signal officer are the issue of instructions and orders of the Signal Corps units, and the personal direction of the signal system and agencies, together with any other Signal Corps activities of his headquarters, both in combat and in rest and training areas.

c. In the employment of his signal units, the signal officer insures that each unit is organized on a functional basis into teams and reliefs which are adequate for the performance of the duties of that unit, and that in each unit a reserve of personnel and equipment is constantly available for the performance of unforeseen duties which may be required in operations. When such a reserve is assigned a mission, a new reserve is formed immediately for further similar employment.

■ 12. STAFF RELATIONS.—The staff relations outlined in this paragraph apply specifically to the division. Those pertaining to higher units are similar but require expansion because of the enlarged and more comprehensive activities of those units. The principal differences between the staff relations of the division and those of the “triangular” division are also indicated. Since the division signal officer has both staff and command functions, his relations with other members of the staff fall under two categories, namely, as a staff officer and as a commander of troops.

a. *As staff officer.*—(1) *With the general staff.*—(a) The signal officer exercises his staff functions under the supervision and coordination of the general staff (par. 9). It is the duty of the general staff to give the signal officer the earliest practicable information of contemplated operations in order that he may have time for necessary planning and preparation. (See par. 80.)

(b) It is the duty of the signal officer to keep the commander and the general staff constantly informed as to the condition and capabilities of the signal system and of the signal troops in order that the commander and his general staff may have at all times the necessary information on which to base plans and orders.

(c) There is but one chain of command, and the commander of the division is in full control of all personnel assigned thereto, and is alone responsible to higher authority for the results obtained by his organization. In accordance with this principle, any directions or orders issued to subordinate units must be transmitted through the proper channels of command. However, after policies and basic plans are decided upon and promulgated, many details are worked out by conference or correspondence between the signal officer and the signal and communication officers of lower and higher units. The matters handled in this manner are confined to routine technical operations or the details of an approved plan. Anything that requires the statement of a new policy or a variation from prescribed methods is handled through the command channel.

(d) A statement of the duties of the signal officer and the various general staff sections with which he may come in contact (for purposes of coordination and supervision) in performing these duties and in obtaining information and facilities which have a bearing on their performance is given in the chart entitled "Division Signal officer and the General Staff Corps." The matters listed under the various general staff sections are set forth so as to indicate solely the particular general staff officer charged with the formulation of policies relating to, and the coordination of, the specific matters. The signal officer does not request a general staff officer for a decision unless announced policies hinder the performance of the signal mission or publication of policies or other coordinating action is necessary for the proper performance of that mission. The special staff works with the general staff under previously announced policies. The various details are worked out among special staff officers in order to relieve the general staff officers of the burden of routine details.

(e) In the "triangular" division the functions of G-1 are performed by the adjutant general.

(2) *With the special staff.*—(a) The following table, subject to change by Tables of Organization, indicates the special staffs (par. 9b (2)) found at various large headquarters.

## DIVISION SIGNAL OFFICER AND THE GENERAL STAFF CORPS

Signal officer	G-1 1	G-2	G-3	G-4	
<p>1. Adviser to the commander and staff on signal matters.</p> <p>2. Preparation of routine and combat orders relating to signal communication, including signal operation</p>	<p>Requirements for suitable space for the signal agencies at a headquarters.</p> <p>Operation of signal agencies in quartering areas.</p> <p>Information as to signal facilities existing in proposed quartering areas.</p>	<p>Reconnaissance measures to obtain information of signal facilities in enemy territory.</p> <p>Signal security.</p>	<p>Location of command posts and axes of signal communication.</p> <p>Mobilization of signal units.</p> <p>Training, including—</p> <p>a. Selection of training sites for signal personnel.</p> <p>b. Preparation of the sections of training directives and orders relating to the training of signal personnel.</p> <p>c. Organization and conduct of schools for the training of signal specialists.</p> <p>d. Training reports and regulations relating to the training of signal personnel.</p> <p>Priorities for the assignment of personnel and equipment to signal units.</p> <p>Technical and tactical control of the signal system of subordinate units.</p>	<p>Construction of signal systems required for shelter, supply, transportation, and hospitalization purposes.</p> <p>New tables of signal equipment and supplies or changes in existing tables.</p> <p>Properly accountability and responsibility relating to signal equipment and supplies.</p> <p>Disposition of captured or excess signal matériel.</p>	<p>Location of supply and evacuation establishments requiring signal communication.</p> <p>Signal operation instructions and signal annexes.</p> <p>Tactical dispositions of combat troops requiring</p> <p>Location of observation posts requiring telephone service.</p> <p>Signal security.</p> <p>Headquarters arrangements.</p> <p>Station lists showing locations of units.</p>

Signal supply including evacuation of signal supply establishments and transportation thereof.  
 Information as to highway circulation and control of traffic therein; circulation maps.  
 Signal communication at the rear echelon of division headquarters, to include handling of periodic reports.

signal communication.  
 Installation, maintenance, and operation of the signal system, including the message center of the unit.  
 Movement of division signal troops on the march and during combat.

Highway circulation and control insofar as the movement of signal supplies and equipment is affected thereby.  
 Procurement of shelter and repair facilities required for signal supplies and equipment.  
 Transportation required for signal supplies and equipment.  
 Salvage of signal supplies and equipment.  
 Property accountability and responsibility.  
 Requisitions.  
 Procurement.  
 Funds and priority in expenditure of same for signal corps purposes.  
 Parts of administrative orders relating to signal supply.

Priorities in distribution of signal equipment and supplies in which there is a shortage.  
 Training of personnel for maintenance and minor repair purposes.

The use of codes and ciphers.  
 Military maps for the use of signal personnel.  
 Information of the location of enemy troops whose activities would affect efficient signal communication, such as hostile artillery locations.  
 Transmission of intelligence estimates and reports.

Priorities in distribution of signal equipment and supplies in which there is a shortage.  
 Training of personnel for maintenance and minor repair purposes.

Signal communication for military police purposes.  
 Quarters areas for division signal troops.

Procurement of personnel for signal supply, maintenance, and repair purposes.

instructions and signal annexes.  
 3. Supervision of the installation, operation, and maintenance of the signal system, including the message center of the unit.  
 4. Command of signal troops assigned to serve his headquarters.

5. Supply of signal equipment and supplies.  
 6. Procurement and operation of signal maintenance and repair facilities.

<sup>1</sup> In the triangular division the functions of G-1 are performed by the adjutant general.

## DIVISION SIGNAL OFFICER AND THE GENERAL STAFF CORPS—Continued

Signal officer	G-1	G-2	G-3	G-4
6—Continued.				Instructions relating to the storage, issue, maintenance, and repair of signal supplies.
7. Technical inspection of signal equipment within limits prescribed by the commander, and recommendations relative to its care and utilization.	Disciplinary action in cases of neglect or abuse of signal equipment. Orders relative to the care of signal equipment.		Condition of equipment with respect to its serviceability for operations; training measures necessary to insure better care and maintenance.	
8. Technical supervision, within limits prescribed by the commander, of all signal operations of the command, including training, assignment, replacement, and utilization of signal personnel of units.	Strength reports indicating the status of units with respect to signal personnel. Orders for the assignment and replacement of signal personnel in conformity with priorities fixed by G-3.	Activities connected with signal security.	Signal operations and the utilization and training of signal personnel. Priorities in the assignment and replacement of signal personnel to units.	
9. Supervision of such activities pertaining to the signal intelligence service as affect the unit.	Disciplinary action in cases of violation of orders relative to signal security.	Use of codes and ciphers and plans governing their use to preventing the enemy from obtaining information.	Training in signal security measures. Requirements for prearranged codes for special tactical operations.	

<p>10. Supervision of such activities pertaining to the pigeon and photographic services as affect the unit.</p>		<p>Orders relative to signal security. Collection and transmission of signal intelligence by all arms.</p>	<p>Restrictions relative to the use of radio or other means.</p>	<p>Plans and orders for the utilization of photographic agencies, including the coordinating of missions required by G-1, G-2, and G-3.</p>
			<p>Plans and orders for the utilization of pigeon agencies.</p>	

In this table, the letter F indicates that the section is usually in the forward echelon, the letter R indicates that it is usually in the rear echelon, and the letters FR indicate that it is usually divided between the forward and rear echelons.

SPECIAL STAFFS OF VARIOUS LARGE UNITS

Section or service	Units					
	Division	"Triangular" division <sup>1</sup>	Cavalry division (horse)	Cavalry corps	Corps	Army
Adjutant general's.....	R	R	R	R	R	R
Antiaircraft.....				F	F	
Artillery.....	F	F <sup>2</sup>	F	F	F	
Aviation.....	F		F	F	F	F
Chaplain's.....	R	R	R	R	R	R
Chemical warfare.....	FR	F	FR	F	F	FR
Coast artillery.....						F
Engineer.....	F	F	F	F	F	F
Field artillery.....						F
Finance.....	R	R	R	R	R	R
Infantry.....		F <sup>2</sup>				
Inspector general's.....	R	R	R	R	R	R
Judge advocate's.....	R	R	R	R	R	R
Medical.....	R	R	R	R	R	R
Ordnance.....	R	R	R	R	R	R
Postal.....		R				
Quartermaster.....	R	R	R	R	R	R
Signal.....	F	F	F	F	F	F

<sup>1</sup> Table of Organization does not show forward and rear echelons.

<sup>2</sup> See (3) below.

(b) **Teamwork** is essential for efficient staff functioning. Not only must there be cooperation between the general and special staffs, between the division staff and the units of the division, and with staffs of higher, lower, and adjacent units, but close collaboration and collective efforts among the members of the special staff are vital in military operations.

(c) The special staff functions under the coordination of the general staff sections. The heads of the general staff sections announce the policies of the division commander. The special staff operates under these directives. Differences in individual special staff plans are settled by the special staff officers concerned, and only in cases of continued disagreement are these differences brought to the attention of the appropriate general staff section for settlement. Such differences, however, can and should be kept to the minimum by

conference and agreement between the special staff officers involved prior to the submission of their plans or recommendations to the general staff. The division commander and his general staff are too busy with other affairs to take time to approve or disapprove the many actions of the special staff that fall under the headings of the established policies. However, the signal officer must not hesitate to go to a general staff section head when it is imperative that his concurrence be obtained, nor should he hesitate to take his problems to the chief of staff or division commander when the situation requires.

(d) In formulating his plan of signal communication, and on other occasions, the signal officer may have occasion to confer with members of the special staff relative to the matters indicated below.

1. *Air officer.*—Locations of advance landing fields; panel stations; pick-up message grounds; means of signal communication to be employed between Air Corps elements on the ground, between division headquarters and Air Corps units, between ground troops and airplanes, and between airplanes; signal supply for attached observation aviation units; etc.
2. *Chemical officer.*—Locations of command posts and signal installations as to suitability from the viewpoint of protection against chemical attack; locations of contaminated areas to be avoided in planning a wire system or messenger routes; signal communication required for attached chemical troops; and transmission of information pertaining to chemical intelligence.
3. *Engineer.*—Collection of information as to existing stocks of telephone poles and other construction supplies in the area as disclosed by engineer reconnaissance; demolition of existing commercial wire lines; signal communication required by engineer troops; and marking of routes; etc.
4. *Quartermaster.*—Availability of transportation for the movement of signal supplies and for messenger use; location of supply establishments operated

by quartermaster troops; and requirements for signal communication for quartermaster troops and other supply establishments serving the division.

5. *Surgeon*.—Signal communication required by medical establishments to be operated by medical troops.
6. *Ordnance officer*.—Supply of pyrotechnics for use within the division in visual communication, and signal communication required for ordnance troops and their activities including the ammunition supply point.

(3) *With infantry and artillery sections of "triangular" division*.—Although shown in the table in (2) (a) above as parts of the special staff of the "triangular" division, the infantry and artillery sections are not so shown in the Table of Organization. These sections, each of which is headed by a brigadier general, have special staff duties, however, in representing their respective arms at the headquarters, and in addition the head thereof may, by orders of the division commander, command elements of the division. The relationship between the signal officer and the heads of these sections when commanding such elements is outlined in FM 11-10; such relationship when they have only special staff duties cover matters mainly affecting signal communication to, between, and within their respective arms.

*b. As commander of troops*.—As a commander of troops the staff relations of the division signal officer are similar to those of any other commander whose unit is directly subordinate to the division; for example, the engineer or quartermaster.

## CHAPTER 4

### TRAINING

■ 13. **EXTENT.**—The extent to which personnel is trained in the field is determined by the orders issued to the field forces. In general, field training is designed to correct deficiencies of personnel assigned to the field forces from the zone of the interior. (For the use of training films, see ch. 6, and for supervision of the training of subordinate units, see sec. III, ch. 8.)

■ 14. **UNIT.**—Commanders of all units are responsible for the training of their units in all operations engaged in by them. The establishment of troop schools by superior commanders contributes to this training, but the bulk of the training of any unit is that given in the unit, and this training is continuous.

■ 15. **TROOP SCHOOLS.**—*a. Considerations.*—Prior to recommending the establishment of a troop school for centralized training, the signal officer considers the following factors:

(1) Number of students requiring training. Usually school instruction of many students in the same subject is more economical of instructors, time, texts, and supplies than is unit training.

(2) Necessity for standardized instruction. Instruction, especially in standardized procedures *between* units, can be given in schools more satisfactorily than in units, and this advantage increases as the number of units increases.

(3) Availability of equipment in addition to unit equipment. In most cases, the use of unit equipment outside of the unit is impracticable and undesirable.

(4) Availability of a small group of instructors whose services can be devoted exclusively to the operation of the school. While the utilization of instructors from units on part time is necessary, a few must be assigned exclusively to the school if it is to be conducted properly.

(5) Time available for instruction. The time required to obtain and install equipment, to obtain texts, and to organize instruction in a school is material, and unless it can be spared for the purpose, unit training is more desirable since it can be initiated more promptly.

(6) Accessibility of the school area to quartering areas of units or the availability of school quarters. If much time is involved in going to and coming from schools, centralized instruction becomes inefficient.

*b. Recommendations.*—When the establishment of a troop school is recommended to a commander, the recommendation will include—

(1) Objective of the school.

(2) Schedule showing courses, subjects, texts, hours of instruction, instructors, and locations of instruction areas.

(3) Draft of instructions governing the operation of the school, selection and detail of students, standards of proficiency, relief or certification of students, and limitations on their subsequent employment in units.

(4) Requisitions for necessary buildings, space, equipment, texts, supplies, and instructors, both for full and part time.

■ 16. OFFICERS.—In addition to the training given an officer in his assigned duties, he is invariably trained in the duties of the next higher grade, unit, or assignment. In the division and the corps, specialization in officer training is secondary to general combat proficiency. In the higher units, specialization is of greater importance, but in any specialty such as wire, radio, photography, etc., the training should be broad enough to cover that specialty.

■ 17. ENLISTED MEN.—As in the case of officers, enlisted men are trained in the duties of the next higher grade or assignment as well as in their assigned duties. The selection and training of noncommissioned officers are of equal importance to those of specialists. Training is prescribed to conform to \*TM 11-450 which covers only the larger portion of signal specialists, and to \*TM 11-410 for pigeoneers.

■ 18. SPECIAL TRAINING EQUIPMENT.—Table of Basic Allowances for Signal Corps lists the special equipment authorized for peace and mobilization training purposes only, which is in

\*See Appendix.

addition to organization equipment. None of this equipment is to be taken into the theater of operations by units, but is available for their use during mobilization training and for the use of schools established in the theater of operations. In addition to certain line construction equipment and supplies and certain radio sets, the following special equipment for the training of radio and telegraph operators is provided:

*a. Code practice equipment EE-81.*—A complete description and detailed instructions as to the installation, operation, and maintenance of code practice equipment EE-81 are contained in \*TM 11-432.

*b. Code transmitter and recorder TG-8-A.*—The operation of the code transmitter and recorder TG-8-A is covered in manufacturer's instructions accompanying this equipment.

\*See Appendix.

## CHAPTER 5

### SIGNAL SUPPLY

■ 19. **DIVISION.**—Division signal supply is completely covered in FM 24-5. (See pars. 25-27.)

■ 20. **CORPS AND CAVALRY CORPS.**—Signal supply of corps troops of the corps and the cavalry corps is essentially the same as that indicated in FM 24-5 for the division, with obvious modifications. The corps signal officers and supply officers of the signal battalion assigned to the corps and of the signal troop assigned to the cavalry corps have similar duties to those of the division signal officer and supply officer of the division signal company or troop, respectively. When the corps or cavalry corps operates independently, the corps signal officer performs the essential functions for all troops of the corps (including the troops of the divisions in the corps) indicated herein for the army signal officer, and the attached service troops are employed similarly to those assigned to an army.

■ 21. **ARMY AND GHQ.**—Paragraphs 22 to 28 are a guide for signal officers in the operations of signal supply in the army and GHQ. The publications and information indicated therein are needed by them in these operations.

■ 22. **PUBLICATIONS AND INFORMATION NECESSARY.**—*a. Publications.*—(1) Tables of Organization (T/O) for each unit included in the army or GHQ.

(2) Tables of Basic Allowances (T/BA) for each arm and service included in the army or GHQ.

(3) Army Regulations (AR) in the 5-, 35-, and 105-series.

(4) Circular 1, and Supply Letters, Office of the Chief Signal Officer.

(5) Signal Corps General Catalog (SCGC).

(6) Technical Manuals (TM), or in the absence thereof instruction books (IB) covering Signal Corps equipment.

*b. Information.*—(1) Compilations of the Office of the Chief Signal Officer:

(a) Procurement status reports.

(b) Signal Corps War Planning Equipment Chart.

(c) Lists of items in Tables of Basic Allowances consolidated to show arms and services using the items.

(d) Signal Corps Maintenance Factors showing for all items the monthly maintenance factors for the zone of the interior and the theater of operations.

(2) Orders and policies of the army or GHQ to include—

(a) Approved war or other plans governing the headquarters.

(b) Field or other operations orders.

(c) Administrative orders or directives governing the preparation of administrative orders or similar instructions.

■ 23. PLAN.—Based upon the publications and information referred to in paragraph 22, and upon any other directives received by him, the chief signal officer of the theater of operations or the army signal officer prepares a plan of signal supply for his headquarters and the troops subordinate thereto, providing for the accomplishment of all the supply duties of the signal officer. The plan is submitted to G-4 of his headquarters for approval and for decision as to the portions thereof which are to be published in paragraph 4 of the field orders of that headquarters, in a signal annex to the field order, in administrative or other orders of that headquarters, or in instructions of the signal officer to those concerned. Among other matters, the plan includes—

*a.* Instructions covering the storage, accounting for, and distribution of codes and ciphers. (See ch. 7.)

*b.* All actions and instructions necessary for the establishment and operation of signal depots or signal sections of general depots to include requisitions for space, both open and covered, buildings, and other facilities, new construction, etc.; a statement for each depot and section showing location, date of opening, character of supplies to be issued thereat, when necessary, and units to be served by it. If in addition to depots, distributing points are to be established, a statement of their locations, times of opening, and organizations served by each.

c. All actions and instructions necessary for the establishment and operation of signal maintenance and repair facilities at depots or elsewhere, together with requisitions for space, buildings, tools, machines, and equipment required for this purpose. Instructions for the guidance of subordinate signal officers as to the forwarding of equipment for repair. Instructions providing for the inspection of all salvaged and captured supplies and the selection and repair of those pertaining to the Signal Corps.

d. Instructions to the signal depot company and other service troops or personnel available as to bivouacs, movements, attachments, etc.

e. Instructions for the guidance of subordinate signal officers or other authorized inspectors as to the technical inspection of signal equipment.

f. Instructions as to the operations of the photographic personnel assigned to his headquarters, including the establishment of facilities therefor and the attachment of portions thereof to subordinate units. Instructions as to the storage, circulation, and projection of training films. (See ch. 6.)

g. Instructions as to keeping records and rendering reports relating to signal supply and the personnel engaged therein.

■ 24. AGENCIES AND UNITS.—A supply section is included in both the headquarters of the army and GHQ signal services, and a depot signal company is an organic part of both these services. The organization and operations of these agencies and units are covered in FM 11-20.

■ 25. REQUISITIONS AND CREDITS.—a. (1) All signal supplies are obtained on requisition. Requisitions are submitted at definite dates to cover needs for specified periods, and at as early dates as possible to cover needs which could not be foreseen in time to permit their inclusion in periodic requisitions.

(2) Nomenclature of all items will conform to that prescribed in Tables of Basic Allowances or in the Signal Corps General Catalog.

(3) Quantities requisitioned will not exceed those authorized in Tables of Basic Allowances unless justification for the additional needs is included. Needs of lower units which can be met from supplies in the hands or under the control of supply

or signal officers are not included in requisitions submitted by those officers.

b. (1) Requisitions bearing the approval of commanders (usually by G-4 for the commander) are submitted to the army signal officer by the—

(a) *Signal officer of a division.*—One requisition for the consolidated needs of the division.

(b) *Signal officer of a corps.*—One requisition for the consolidated needs of corps troops.

(c) *Supply officers of army troops.*—One requisition for the consolidated needs of each separate unit of army troops.

(2) The army signal officer—

(a) Checks to see that all requisitions are received by him at the times specified. If any are missing, he initiates action to obtain them and to assure their future timely receipt.

(b) Edits all requisitions for quantity, authenticity, nomenclature, and form, and takes action relative to the supply thereof.

(c) When the supplies are available in an army depot, fills the requisition from stocks at his disposal in that depot, placing the requisitioned supplies at the disposition of the requisitioning unit. When the supplies are not available in an army depot, and when there are no credits of the unavailable supplies in communications zone depots, consolidates the requisitions to the extent desirable, obtains approval by the army commander ((1) above), and forwards the requisitions directly to the regulating officer.

c. The Signal Corps representative on the staff of the regulating officer transmits a copy of each requisition received by him to the proper depot in the communications zone, with such shipping instructions as may be approved by the regulating officer. Upon arrival at the regulating station the supplies are shipped either in the daily train to the railhead of the requisitioning unit or by train to a signal depot, depending generally upon which was specified by the army signal officer.

d. When divisions and corps have been allotted credits in army depots, requisitions after approval (b (1) above) by the commander of the division or corps are forwarded directly to the army signal depot by the division or corps signal

officer. The depot releases the supplies to the division or corps. Similarly, if the army has been allotted credits in a communications zone depot, the army signal officer forwards his requisitions, after approval by the army commander, directly to the designated depot, furnishing a copy of each to the regulating officer. The Signal Corps representative on the staff of the regulating officer takes the necessary action to insure prompt shipment. Upon arrival of the supplies at the regulating station, they are forwarded to the railheads of the subordinate units requiring them or to the army signal depot, whichever case is applicable, in the manner described in *c* above.

*e.* Requisitions from troops and installations in the communications zone are submitted to the signal officer, communications zone, and the action taken by him thereon is similar to that indicated in *b* (2) above for the army.

■ 26. STORAGE, SHIPMENT, AND ISSUE.—*a.* Army depots are not usually established until an operation involving a considerable portion of the troops comprising the army is imminent. Prior to the establishment of an army signal depot, signal supplies are forwarded from the communications zone depot, through the regulating station, to the railheads of army and corps troops, divisions, or smaller units on missions which separate them from their division. When an army signal depot is established, signal supplies for a division, when available in that depot, are usually secured from that depot by division motor transportation designated for the purpose. (See par. 27.)

*b.* Upon arrival at a railhead or upon release by an army depot, signal supplies requisitioned by a division come under control of the division signal officer. These supplies may be delivered to the using organizations in any one of several ways in accordance with the orders of the division commander. Delivery is usually made to the division signal distributing point (which usually will be the division signal dump) by the transportation which has secured the signal supplies from the army depot or the railhead, and it is then obtained from the signal distributing point by requisitioning organizations with their own transportation. Transportation of using organizations may secure the supplies directly from

the supply point. Vehicles which secured the supplies at the railhead or depot may deliver directly to using organizations. In exceptional cases transportation of the division signal company or signal troop may secure and deliver signal supplies to organizations of a division. Units of corps troops usually secure their signal supplies from army depots or corps railheads. Army troops usually secure their signal supplies directly from army depots or designated railheads.

c. In offensive situations when the division signal dump is established for the distribution of signal supplies, the time and place of establishment must be such that subordinate units may draw their supplies and return to their organizations prior to the hour of attack. When signal supplies are to be distributed from a point or points other than the signal dump, the locations of such distributing point(s) should be stated in the unit administrative order or paragraph 4 of the field order if no administrative order is issued, in paragraph 4 of the signal annex (if issued), and in paragraph 4 of orders to signal units. A signal distributing point should be located at a point on a road accessible to the type of transportation employed and near a suitable turn-around.

■ 27. **TRANSPORTATION.**—All transportation of signal units carries organizational equipment and constitutes the trains of such units. It should not be separated therefrom. All transportation required for the movement of signal supplies is usually obtained from transportation pools maintained and operated by GHQ, army, corps, and division. Application therefor is made to the quartermaster of the headquarters in conformity with the commander's policies and orders.

■ 28. **FIELD DEVELOPMENT.**—The normal development of all signal equipment issued to troops is accomplished in laboratories in the zone of the interior. In order that defects in adopted equipment and field expedients adopted to overcome inadequacies of design may be available for study in connection with such development, signal officers of all units will report to higher authority the defects noted and expedients used by them during operations. In inspecting and selecting captured material, similar action will be taken with regard to apparent improvements in enemy equipment.

## CHAPTER 6

### PHOTOGRAPHY

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#### SECTION I

#### GENERAL

■ 29. **PURPOSE.**—(See par. 3k.) Photography is used in the field for the following purposes:

- Mapping.
- Operations.
- Training.
- Record.
- Public information.
- Identification.

■ 30. **MAPPING.**—The employment of photography for mapping purposes is not within the scope of this manual. It is of primary concern to commanders, staffs, the Corps of Engineers, and the Air Corps, and is covered in other publications.

■ 31. **OPERATIONS.**—While in special situations photographs taken from the ground may supply information making their use desirable in connection with operations, those taken from the air are most suitable for this purpose. These may be still photographs or mosaics to serve in lieu of maps or motion pictures recording the results of reconnaissance. The employment of photography for this purpose, except in the special situations referred to above, is also not within the scope of this manual. It is of primary interest to commanders, staffs, the Corps of Engineers, and the Air Corps, and is covered in other publications. (See FM 30-20, Military Intelligence, Role of Aerial Photography, for references thereto.)

■ 32. TRAINING.—*a. General.*—Still and motion picture photographs taken both from the ground and from the air are valuable in the training of troops and units of all arms and services. Still photographs for reproduction purposes in training literature, lantern slides, film slides, and motion pictures, both silent and sound, are the forms most generally used. The production, duplication, distribution, and accounting for all such visual aids used for training purposes by the arms and services are responsibilities of the Signal Corps. In general, material for training use is especially photographed in such a manner as to emphasize the instructional points of view, but suitable material may be selected from the photographic records of current or previous operations, from photographs made for engineering or analytical studies, or for other purposes. The peacetime production of pictorial training materials contemplates the probability of their use in mobilization training.

*b. Still pictures.*—Still pictures for use in illustrating manuals and other texts must be clear and sharp, and must have relatively large image sizes and high tonal contrasts so that details will reproduce well in the engraving process. In many cases, reinforcement of the important details with black waterproof ink, even to the extent of building up the illustration as a line drawing and then bleaching out the undesired photographic details, improves the reproduction qualities of the illustration. Requests for this work may originate from local training activities or other agencies. Any still picture unit can perform the photographic phases of this work.

*c. Lantern slides.*—Lantern slides are photographic transparencies on glass made from photographic negatives. Image sizes should be kept as large as possible, nonessential details should be subdued or eliminated, and all lettering should be bold. Illustrations showing large amounts of detail do not usually make good slides, and it is frequently better practice to make separate slides of each of several sections. While lantern slides are generally superior to film slides (*d* below) in the quality of the projected image, lantern slides are subject to breakage from heat during projection, or from rough handling, the continuity of their use is not fixed, and cost and labor

of producing many copies are relatively large. Requests for lantern slides may originate from local training activities. Any still picture unit is equipped to do this work.

*d. Film slides.*—The same care in selecting and preparing material for lantern slides should be used in preparing film slides. The production of film slides requires a special motion picture camera set-up to make new negatives from the positive illustrations used. It is customary to include from 25 to 100 illustrations on each strip of film slides, arranged in the order of use. Strips of film slides are generally produced on a project basis approved by the War Department or by the commander of the field forces. They are not normally produced by photographic units below those of GHQ. Once a negative is available, copies can be made rapidly and very cheaply in any standard motion-picture laboratory. The principal advantages of film slides for instructional use are—

(1) Any illustration can be held on the screen as long as desired.

(2) They are not readily subject to breakage.

(3) They are compact and of light weight.

(4) The continuity is fixed.

*e. Training films.*—(1) *Reference.*—The detailed and comprehensive instructions governing training films contained in AR 105-260 are not repeated in this manual.

(2) *Production.*—In peacetime, War Department approval is required for each project, and production is performed by special units operating directly under the Chief Signal Officer. In case of mobilization, many may be produced by the Signal Photographic Laboratory, GHQ, as directed by the commander of the field forces. (See FM 11-20.)

(3) *Value.*—These films are used with and to amplify other instruction. They are particularly valuable in demonstrating operations and techniques which are not susceptible to simple explanation and those in which an appreciation of movement is vital to the understanding of the subject being taught. Detail can often be shown on a film better than it can be shown by a demonstration on the ground. Films are prepared for use to emphasize the demonstration and explanation phases of the training cycle.

(4) *Lists*.—All training films are released in both standard (35-mm) and substandard (16-mm) sizes. With the exceptions of a few films for manipulative training that are silent, all late films are of the sound type. Lists of available films giving serial numbers, dates of production, summary of content, number of reels, and running time are published from time to time in War Department circulars.

(5) *Use*.—(a) The Signal Corps is concerned primarily with the production and distribution of training films and does not attempt to provide exhibition service therefor except at the immediate headquarters where equipment and personnel are available within signal units. Projection equipment is procured by the Signal Corps, as directed by the War Department, for permanent issue to key organizations.

(b) Signal officers of all units keep lists of available films and film slides up to date, bring them to the attention of their unit commanders, and, when so directed, operate a booking and distributing organization therefor.

(c) The chief signal officer of a theater of operations provides such films and projection equipment as may be available for the field forces, prescribes procedures for obtaining, safeguarding, and circulating the films, and makes appropriate recommendations to higher authority for the production of new films.

■ 33. *RECORD*.—a. A permanent pictorial record of the activities of each division, corps, or army has great historical value. This record shows all phases of training, routine, ceremonies, camp life, and active operations. Where operations can be observed, the military value of this record is relatively small, but for studies by distant headquarters and in the postwar period it provides an excellent medium for the study of operations, the evolution of new doctrines, and the development of new equipment.

b. In the theater of operations, general directives are issued from GHQ as to the general types of pictures to be secured and the ratio to be striven for between the types. The signal officer under whom photographic personnel operate coordinates and directs such work in accordance with the general directives, and on his own responsibility initiates

such projects as his headquarters may desire or may consider desirable.

■ 34. PUBLIC INFORMATION.—*a.* Photographs have a wide use in connection with desirable publicity and for counterpropaganda. Those taken for this purpose differ radically from those made for training and record purposes. News pictures portray the human interest side of war and they, together with their accompanying captions, are designed to produce a particularly favorable reaction of the civilian population toward the Army. These pictures tell a story and include photographs of important events, military operations, outstanding heroes, refugees, devastated areas, activities of welfare organizations, prisoners of war, captured enemy material, and similar objects of interest. Such pictures made from unusual angles or unfamiliar viewpoints often have increased value.

*b.* News-disseminating agencies demand such pictures in large quantities, and in order to meet that demand and to minimize the necessity of civilian photographic activities in the theater of operations the signal officer of any unit provided with photographic personnel assures the availability of suitable photographs for the purpose. For instructions as to accredited civilian photographers, see FM 30-25.

*c.* Policies as to the release of such photographs for publication, together with policies governing the release of other news, are prescribed by the commander, and signal officers cooperate in such release with G-2 who normally is charged with the publicity activities of the unit. See AR 600-700 regarding the responsibility for public relations in peacetime.

■ 35. IDENTIFICATION.—Photographs of individuals to be placed on passes, passports, and other official documents are produced by units from army and higher headquarters. These are generally of a standard type and size. In case a need arises or exists for the production of large quantities of such pictures in organizations not provided with identification units, request is made through channels to the proper authority for the temporary attachment of an identification unit. Signal officers having such units temporarily under their control are responsible for the coordination of the work and the efficient use of the units during such periods.

■ 36. AGENCIES.—*a.* The following field photographic agencies, the organization and operations of which are covered in FM 11-20, are provided:

- (1) Photographic section, headquarters, signal service, GHQ.
- (2) Signal laboratory, photographic, GHQ.
- (3) Signal companies, photographic.

*b.* Photographic units are not provided as an organic part of organizations below the army. The signal photographic company is organized to permit the detachment of still or motion picture operating personnel for duty with corps and divisions within the army. In order to insure best results, the same photographic assignment unit usually operates continuously with the same corps or division as long as it is a part of the army. This practice will not operate to prevent the detachment of assignment units when such detachment will best meet the needs of the army. The entire photographic service in the theater of operations operates as a closely integrated unit whose functions are to provide local service where required and to gather, produce, and feed back to the higher organization pictorial material for training, record, and public information use.

*c.* General instructions regarding the handling and disposition of negatives of the various classes are issued from GHQ. Negatives produced by photographic companies are forwarded to a central file after they have served the immediate local needs.

*d.* An assignment unit consists of a group of specialists in certain types of photographic work. While on assignment still-picture personnel should not be expected or called upon to perform motion picture work, and likewise, motion picture personnel should not be expected to perform still picture work in addition to their regular work.

■ 37. FIELD OPERATING INSTRUCTIONS.—Operators, both still and motion picture, observe the following general rules when preparing for and when taking photographs for record or public information purposes:

*a.* Equipment is checked to insure that the proper type is available for the mission, and for completeness and working condition before going out on assignment.

b. The problem presented by the assignment is studied, and a plan of operation or coverage is determined upon as far in advance as possible. Cameramen must, however, be prepared to take advantage of unexpected occurrences and to secure photographs under the changed conditions. Such pictures frequently are of far greater value than those originally sought.

c. Ample film including a reserve supply is taken along.

d. Operators exercise their talent and ingenuity in composition and arrangement of the subject so as to bring out all the desired features. Proper selection of camera angles, camera height, and choice of backgrounds can do much to stress the desired details and minimize those that are non-essential.

e. Operators learn to perform all operations in a certain order so that the possibility of error is minimized and the performance of the work speeded up.

f. A brief, concise, well-worded description or caption invariably accompanies each exposure. This may be hastily outlined in a penciled note at the time the exposure is made, then written up fully and attached to the exposed films when sent to the laboratory for development. *Do not trust to memory.* Make notes regarding the subject material at the time the exposure is made. The caption should answer the questions: Who? What? When? Where? Why? How? Caption sheets should contain the following information:

(1) Place and date.

(2) Names of individuals, organizations, or other description of the subject.

(3) Name of operator.

(4) Purpose or objective or other special conditions.

g. When loading cut films each film is numbered in one corner with a pencil to correspond with the number on the film holder. Later each caption is numbered to correspond to its film number. On roll films and film packs for still cameras, a number is given to each roll or pack. This number is used on the corresponding caption sheet, and captions are arranged to correspond to the order of exposure.

h. On motion-picture film, each scene is slated or punched with a scene number before exposure. Captions and descrip-

tive notes follow in sequence corresponding to the order of the scenes on the negative. Separate caption sheets are made for each roll of motion-picture negative.

*i.* In covering events with motion-picture cameras, a definite plan is worked out in advance. This plan provides for changes of viewpoint, close-ups, medium shots, and long shots in proper balance to permit ready cross-cutting in editing. Excessive scene lengths and the sameness of viewpoint or uniformity of angle must be avoided. On important events where two or more cameras are in use, a division of work can be made to provide the necessary variety and coverage for editorial purposes. Utilization of the various lenses of different focal lengths provided on each motion-picture camera will aid in improving the variety of scene composition.

*j.* As soon as practicable after exposure, negatives after being secured and sealed and accompanied by complete captions are forwarded to the designated laboratory for development and printing.

■ 38. EQUIPMENT AND SUPPLIES.—*a. Authorized.*—Table of Basic Allowances for Signal Corps specifies the equipment and supplies authorized for issue to the agencies mentioned in paragraph 36.

*b. Description and use.*—The major items of authorized equipment and supplies and their use are described in paragraphs 39 and 40 and in the sections which follow.

■ 39. NEGATIVE MATERIAL.—*a.* A great variety of negative materials classed according to color sensitivity is available. The general classes are infra-red, panchromatic, orthochromatic, and process or noncolor sensitive films. The successful accomplishment of a photographic mission is dependent upon the selection and use of negative materials designed for the purpose.

*b.* Infra-red negatives are designed to work with light from the extreme red end of the visible spectrum and from invisible light in the region beyond. Successful use of this film requires the use of heavy filters. By using filters under suitable conditions, night-effect scenes are produced in bright daylight, and other unusual pictorial effects may be secured. Some use may also be made of this material in military in-

telligence work and other military applications of a scientific nature. The storage or shelf life of this film is very short, and it should be kept in a cool place, preferably refrigerated, at all times because it can be easily fogged by exposure to heat. After exposure it should be developed as soon as possible in absolute darkness.

c. Panchromatic negatives are sensitive to all wave lengths of the visible spectrum. In some types, a slight decrease in sensitivity in the green region is built into the film to permit development under a very faint green safelight. Best results are secured in development by working in complete darkness using the time and temperature method. A panchromatic negative properly corrected by filters can be made to reproduce in monochrome all the colors of the spectrum in their relative tones of brightness. By proper selection and use of filters, many colors can be subdued, accented, or even eliminated on the completed picture image. By far the majority of negative materials designed for exterior as well as interior work belong to the panchromatic class. A wide range of sensitivity or speed is available in the various types designed for different classes of work. They range all the way from the very slow panchromatic process films for copying to the extremely fast materials intended for news use under very adverse light conditions. Assignment units are normally supplied with two or more types of the fast films to enable them to use the type best suited for the particular light conditions encountered.

d. Orthochromatic negatives are sensitive to all bands of the spectrum except the red. At present they are little used in exterior work by professionals. They are used however in several types of commercial work and as a special-purpose film in copying because of the relatively higher contrast. They can be processed under a red safelight.

e. Process or noncolor sensitive films are special-purpose materials not used outside the studio. They are a very slow, high contrast material widely used in copying diagrams, charts, printed or typed material, and for use where extreme contrasts are desired. They have little or no sensitivity in the green or yellow regions of the spectrum and are insensitive to red light.

■ 40. LIGHT OR EXPOSURE METERS.—*a. Description.*—Meters of convenient size designed for use in measuring the intensity of light, and correlating such measurements with the exposure of different types of negatives have come into general use in recent years. These meters consist of a photo-electric cell or a plate of light-sensitive material which generates minute amounts of electrical current when exposed to light. This photo-electric cell is connected in series with a small resistance and a microammeter. The deflection of the meter needle may be scaled to read in lumens or in an arbitrary numerical system. Built into the cases of these meters are conversion scales to correlate the meter readings with the film speed, the length of exposure, and the aperture to be used with the various exposure times. Some special purpose meters are graduated to read exposure and aperture settings directly.

*b. Use.*—(1) Exposure meters are valuable aids in determining the exposure to be used under specific light conditions with a particular type of film. Successful use necessitates that the operator know the film speed rating, on his meter, of the negative material used, and that he know the idiosyncrasies, if any, of his particular meter. At the present time, wide variations exist between meters of identical type made by the same manufacturer. In other words, they are difficult of standard calibration in manufacture, and each operator should determine the correction factor for his individual meter by making several experimental exposure tests before relying wholly upon his meter for definite exposure data.

(2) Exposure meters are very delicate and are subject to damage by shocks from being dropped or bumped, from excessive moisture or water, and from exposure to excessive heat or prolonged exposure of the photo-electric cell to the direct rays of the sun. In practice where several meters are in use, as in a photographic company, provision should be made for checking all meters periodically to determine that no important changes have occurred in the functioning of the meters. One method used successfully by several of the large motion-picture producers is to build an exposure box or tube with a standard 6-volt automobile headlight bulb mounted in one end and an opening at the other end for the application

of the sensitive cell of the meter in such a manner that no light except from the bulb reaches it. A 6-volt battery, a rheostat, and an ammeter in series with the bulb are used to control the current applied to the lamp. A standard amperage should be selected slightly below the maximum operating current for the lamp to insure long lamp life. By using the same amperage with all meters for successive tests, important variations in the performance of the meters may be determined and a corrective factor applied.

(3) In exterior photography it is customary to use the meter to measure the intensity of reflected light from the object to be photographed. Where wide variations in light intensities occur, it is good practice to measure the light reflected from the brightest portion and from the duller portion separately and then strike an average. When used on interior work where extremely dark areas occur in the scene, measurements of the reflected light from the bright areas may be used, or the intensity of the incident light on the brightest illuminated object may be used as a guide. In either case a corrective factor ascertained from experience should be worked out and applied. Each operator must work out a uniform method of use and consistently follow that method if he is to use his meter most effectively. When so used, meters are invaluable aids in maintaining uniformity of exposure under varied lighting conditions.

## SECTION II

### STILL PHOTOGRAPHY

■ 41. GENERAL.—The two standard sizes of camera equipment in use at present are the 4- by 5-inch and 8- by 10-inch equipments. Another size will be adopted for identification picture production and another for mini-camera use in case of mobilization. All cameras, accessories, and supplies are of commercial design and type. Cut films and film packs are used exclusively in the 4- by 5-inch and 8- by 10-inch cameras. Mini-cameras use small rolls of perforated 35-mm motion picture film.

■ 42. CAMERA EQUIPMENT, NEWS TYPE, 4- BY 5-INCH.—*a. Description.*—This equipment is not stored or issued as a com-

plete unit. It is necessary to requisition each part as listed in (2) below in order to obtain a complete working unit.

(1) The camera PH-47-A, the basic unit in this equipment, is a 4- by 5-inch camera of commercial design, equipped with a built-in focal plane shutter. It is normally fitted with a 6- or a 6½-inch lens of  $F$  4.5, or better, working aperture, mounted in a between-the-lens shutter. Additional lenses of longer or shorter focal length may be supplied mounted in shutters on extra lens boards for use in special situations.

(2) The complete camera equipment includes—

- 1 camera PH-47-A.
- 1 tripod PH-121.
- 1 bag, changing PH-105.
- 1 cloth, focusing PH-130-A.
- 12 holders PH-81.
- 1 adapter PH-110.
- 1 holder PH-183.
- 1 set of glass filters.
- 1 synchronizer, photo-flash.
- 1 lens, anastigmatic  $F$  4.5 6-inch focal length mounted in shutter with flange.
- 3 boards, lens PH-119.
- 1 exposure meter PH-77-A.
- 1 case PH-83.

*b. Use.*—(1) This is the standard all purpose camera equipment for use by assignment units. The use of both types of shutters permits accurate exposures from 1 second to 1/1000 second as well as bulb and time exposures. At shutter speeds of less than 1/25 second it may be used as a hand camera, and at the longer exposure it is used on a tripod.

(2) The 6-inch lens is used on all general work. The use of a photo-flash synchronizer makes it possible to use this camera in obtaining action scenes under very adverse light conditions and at night. The set of filters supplied makes it possible to obtain dark sky or cloud effects to improve pictorial backgrounds and to emphasize or minimize certain colors in the scene photographed.

(3) In addition to its primary use in view and action photography, it may be used to copy illustrations and for identification work where a limited number of such pictures

is required. The use of a masking slide in the back of the camera permits making two identification pictures on each 4- by 5-inch negative.

■ 43. CAMERA EQUIPMENT, 8- BY 10-INCH VIEW.—*a. Description.*—This equipment is not stored or issued as a complete unit. It is necessary to requisition each part as listed in (2) below in order to obtain a complete working unit.

(1) The camera PH-195-A, the basic unit of this equipment, is a standard commercial camera designed for tripod use, having a ground glass focusing back and with a rising and falling front, and with various tilts and adjustments to provide great flexibility in photographing equipment, buildings, etc. It is normally fitted with a lens which is of the convertible type providing focal lengths of  $23\frac{1}{4}$  inches,  $18\frac{7}{8}$  inches, and  $11\frac{7}{8}$  inches. This lens is mounted in a between-the-lens shutter which provides for exposures ranging from 1 to  $\frac{1}{100}$  second as well as bulb and time exposures. Its working aperture varies from *F* 6 to *F* 7.7 depending upon the number of elements used. A wide angle lens mounted in a shutter on a separate lens board is also provided. Other special purpose lenses may be used but they are issued from the laboratory only as special need arises.

(2) The complete equipment includes—

- 1 camera PH-195-A.
- 1 lens mounted in between-the-lens shutter on a lens board.
- 1 lens, wide angle, in shutter mounted on extra lens board.
- 1 cloth, focusing PH-130-A.
- 1 bag, changing PH-105.
- 1 tripod PH-124.
- 12 holders PH-84.
- 1 holder PH-184.
- 1 set of 4-inch filters.
- 1 exposure meter PH-77-A.
- 1 synchronizer, photo-flash.
- 1 case PH-85.

*b. Use.*—(1) This camera may be issued to assignment units where it is necessary to make photographs of large groups, large pieces or assemblies of equipment, and in other cases

where maximum definition and large image sizes on the finished photographs are required. Because of its weight, size, slow shutter speeds, and the necessity of a tripod, it is not suitable for news or action photography. In general, its use will be restricted to those cases where pictures from 4- by 5-inch negatives, or enlargements therefrom, will not meet the requirements as to the detail content in the finished work.

(2) For studio use, it is a very versatile camera, and may be used for commercial type work and for portrait and copying work, although special purpose equipment is normally supplied for the latter two types of work.

■ 44. IDENTIFICATION CAMERA EQUIPMENT.—*a. Description.*—

(1) While a definite camera has not been adopted as standard, provision must be made for such equipment to fulfill photographic missions of the Signal Corps. A camera of commercial design will probably be adopted which will produce negatives of the size adopted as the standard for military identification cards.

(2) Pending the adoption of a standard camera, it is impossible to list in detail all accessories, but a complete equipment will contain—

- 1 camera with lens and shutter.
- 1 tripod or mount.
- 1 plain background.
- 1 printer.
- 1 set of print developing accessories.
- 1 exposure meter PH-77-A.
- 1 large changing bag.

Several lights with reflectors for illuminating the subject.

Developing tanks.

Other additional items necessary to establish and operate a small developing and printing laboratory and to complete the finished identification cards.

*b. Use.*—This equipment is designed to produce standard size identification photographs. It is probable that the card as well as the photograph will be printed by photographic means on a single piece of paper to prevent the substitution of pictures, and these cards will be issued in small celluloid cases.

■ 45. MINI-CAMERA EQUIPMENT.—*a.* While the mini-camera equipment has not been adopted for military use, it is inevitable that this type of camera will find considerable use in certain types of work, especially in forward areas and other places where the more bulky equipment involves unnecessary hazards to the operator or it is inconvenient or impossible to use. This type of camera uses perforated motion-picture film in rolls sufficient for 35 exposures. The picture area is 1 by 1½ inches or double frame size. The camera adopted will be of American manufacture of commercial design. The equipment will consist of the camera with one or more lenses of different focal lengths and a carrying case. If a built-in exposure meter is not available, one exposure meter PH-77-A will be supplied.

*b. Use.*—This camera is designed primarily for hand use but may be used on a tripod. The film may be developed on standard motion-picture developing machines or in special tanks. Because of the extremely small size of the negatives produced, it is necessary to enlarge all prints.

■ 46. SPECIAL PURPOSE CAMERAS.—The 8- by 10-inch copying, enlarging, and reducing camera and the 8- by 10-inch portrait camera are classed as special purpose equipment.

*a. 8- by 10-inch copying, enlarging, and reducing camera equipment.*—This equipment is not stored or issued as a complete unit. It is necessary to requisition each part as listed in (1) (b) below in order to obtain a complete working unit.

(1) *Description.*—(*a*) This camera is designed for studio use in copying prints, negatives, making lantern slides, transparencies, etc. It is of standard commercial design and is not normally supplied with a stand which may be adjusted through a vertical arc of 180°. It is normally fitted with an anastigmatic lens of 12-inch focal length mounted in a between-the-lens shutter, although lenses of greater or lesser focal length may be readily used.

(*b*) The complete equipment consists of—

- 1 copying, enlarging, and reducing camera 8- by 10-inch PH-120-A.
- 1 laboratory stand with copy holder.
- 1 kit of masks.
- 1 lantern slide attachment.

12 holders PH-84.

1 12-inch anastigmatic lens, *F* 6.3 or better, mounted in shutter.

12 holders PH-88.

3 boards, lens 11 by 11 inches.

(2) *Use*.—This camera is issued to photographic companies and laboratories for studio use, in making copy negatives of all kinds, copying charts, diagrams, photographs, etc., and in making lantern slides.

*b. Portrait camera outfit*.—This outfit is not stored or issued as a complete unit. It is necessary to requisition each part as listed in (1) (b) below in order to obtain a complete working unit.

(1) *Description*.—(a) This is a standard commercial outfit. It makes 8- by 10-inch negatives and is normally equipped with a portrait type lens having an approximate focal length of 19½ inches used with a studio type shutter.

(b) The complete outfit includes—

1 camera, studio, 8- by 10-inch, with a sliding ground glass carriage.

1 portrait stand.

12 8- by 10-inch cut film holders.

1 portrait lens, approximately 19½-inch focal length, with studio shutter.

1 head screen.

1 back drop or screen.

1 reflector on stand.

2 incandescent lamps, 1,000-watt, with reflectors and stand.

(2) *Use*.—This outfit is designed primarily for making studio portraits and will not normally be supplied to photographic organizations below GHQ.

■ 47. LABORATORY EQUIPMENT (STILL PICTURE).—*a*. It is not within the province of this manual to describe in detail all of the various items of equipment used in laboratory work. The major items required are negative developing equipment, printing and enlarging equipment, and print developing and drying equipment.

*b*. A photographic company must be equipped to develop small rolls of 35-mm negatives, 4- by 5-inch negatives, and

8- by 10-inch negatives, and to make prints and enlargements from those negatives.

c. The quantity of equipment and the arrangement of the laboratory lay-out should permit the handling of large quantities of negatives and the production of large quantities of prints and enlargements. Under some conditions it may operate on a 24-hour-per-day basis.

d. The still-picture laboratory section of the Signal Photographic Laboratory, GHQ, will be similarly equipped except that it has more elaborate printing and enlarging facilities and equipment for maintaining a comprehensive filing system for negatives.

### SECTION III

#### MOTION PICTURE PHOTOGRAPHY

■ 48. STANDARD PRACTICES.—*a.* In producing motion pictures for record and public information, the 35-mm size sound picture has been adopted as the basic standard for negative and sound recording purposes. Consequently motion picture units are normally equipped with 35-mm cameras and recording equipment for production use. Production in black and white is the standard.

b. (1) In producing training films, prints are produced in both the 35-mm sound film and the 16-mm sound film sizes, the latter being made by optical reduction from 35-mm negatives.

(2) The "double system" of sound picture recordings is the standard. This system produces sound and picture negatives on separate films and provides sound and picture quality superior to that possible on "single systems," and greatly simplifies the laboratory and editorial problems. The composite sound and picture print is obtained in the printing process.

(3) Modern newsreel and instructional film practice is to photograph most events with silent cameras and "dub" in the sound later. Consequently, the majority of motion pictures made in the combat zone will be photographed silent. Natural sound recordings will be made only where the story cannot be told satisfactorily by "post recording" methods.

■ 49. CAMERA EQUIPMENT IN GENERAL.—*a. Speed.*—The standard speed of all 35-mm cameras is 24 exposures per second.

which, when used with a 170° shutter opening, results in exposures of 1/51 second per frame.

*b. Drive.*—Motor drive is standard for all cameras except that the light camera may also be spring driven. Hand-cranking is used only as a last resort. Uniform and steady hand-cranking at the rate of three turns per second is very difficult, and a hand-driven camera almost invariably produces unsteadiness of the scene on the projection screen.

*c. Sound recording systems.*—Two systems of sound recordings on film are in general use commercially. They are the variable density and variable area systems. In the variable density system, the record appears as a ladder effect, with alternating light and dark areas extending across the entire width of the track. In the variable area system the record appears as an irregular sawtooth effect from one or both sides of the track, resulting in variations in the width of the clear and dark areas. While the variable area system is standard with the Signal Corps in peacetime production, it may be necessary to use both systems in an emergency because of the difficulties involved in securing sufficient equipment of suitable characteristics on short notice. The reproduced sound from either system is approximately identical.

*d. Exposure area.*—The standard camera provides a picture exposure area of 0.631 inch by 0.868 inch. This is placed off center in the area between the sprocket holes to provide for a sound track area in printing. The maximum width of the sound track is 0.084 inch, which is closely approximated by variable density recorders. Variable area recorders use a slightly narrower width. The width of the actual recordings used does not alter the width of the space reserved for the sound record.

*e. Supply.*—(1) Motion picture camera, recording, and power equipments are not stocked or issued as complete units. Reference should be made to the latest Table of Basic Allowances for Signal Corps for the individual listing of component parts and accessories before requisitions are prepared.

(2) In requisitioning replacements of lens and camera accessories, a full description, including the serial number, of the camera to be used should be given. In requisitioning replacement components and accessories of sound recording

and power equipments, a complete description including serial numbers, if any, of the equipment with which they are to be used should be given.

(3) Much of the equipment mentioned in paragraphs 50 and 51 is described only in general terms because of the very limited distribution and the special nature of the equipment involved. Where such equipment is to be procured, individual specifications must be prepared on many separate items in order to obtain the latest and most suitable types of commercial equipments.

*f. Use.*—(1) Detailed instructions as to the method of operating the various types of motion picture equipment described will not be attempted in this manual. Reference should be made to the manufacturers' descriptive handbooks on cameras, recorders, etc., issued with such equipment and to commercial texts on various phases of motion picture technique.

(2) A good reference book for motion picture cameramen is the "American Cinematographers Handbook and Reference Guide." For laboratory practice and procedures, reference should be made to "Motion Picture Laboratory Practice," a compilation by the Eastman Kodak Co., and to the "Journal of the Society of Motion Picture Engineers." Sound recording principles and practice are well covered in "Motion Picture Sound Engineering," compiled by the Academy of Motion Picture Arts and Sciences, and "Applied Acoustics," by Olsen and Massa, is a good reference work for recordists and sound engineers. Suitable reference works available from commercial sources will be supplied on Tables of Allowances to key specialists and motion picture units.

■ 50. STANDARD RECORDING CAMERA.—*a. General.*—The present standard motion picture camera used with recording equipment is one in which the camera and view finder rack over to permit scene composition directly through the lens in its operating position.

*b. Magazines.*—It uses external magazines of 400- or 1,000-foot capacities and is equipped with a lens turret for four lenses.

*c. Tripods and cases.*—Tripods for use with these cameras are of the gyro and frictionhead types. Each camera is sup-

plied with a carrying case and an accessories case with accessories such as a view finder, a matte-box, cranks, filters, extra belts, etc., and a magazine case with three 1,000-foot magazines.

*d. Sound recording equipments.*—(1) *Studio.*—The studio type sound-recording equipment consists of a studio type recorder, including microphones, microphone amplifiers, a four-position mixing panel, a main amplifier, noise-reduction amplifier, attenuators, and a recorder, together with all necessary cables for connections between elements of the system. The recorder is driven by a 220-volt, 60-cycle, 3-phase motor. This equipment while designed for studio use, with amplifiers, etc., mounted in a rack, is mounted in a panel-body truck in such a manner that it may be removed easily in a few minutes.

(2) *News.*—The news type sound-recording equipment comprises the same general elements as the studio-type equipment, except that the equipment is built in cases, so far as practicable, and with extra carrying cases for all equipment not so mounted. It is easy to transport.

(3) *Power equipment.*—The power equipment for driving both types of equipment consists of a 36-volt bank of extra heavy-duty storage batteries, a 1-kilowatt d. c.-a. c. converter with 220-volt, 60-cycle, 3-phase output, and with frequency control equipment and meters. Eight hundred feet of 5-conductor, rubber-clad cables, designed for interchangeable use as microphone or camera cables, are supplied. A suitable tungar charging equipment is supplied for charging batteries from alternating-current lines. Two 12-volt d. c. motors are also supplied each sound-picture unit for emergency use in case of failure of the power equipment or where the regular power equipment cannot be used.

*e. Lens equipment.*—The lens equipment normally consists of American made lenses as indicated below. Telephoto lenses will also be supplied.

- 1 35-mm or wide angle *F.* 2.3.
- 1 50-mm or 2-inch *F.* 2.3.
- 1 75-mm or 3-inch *F.* 2.3.
- 1 105-mm or 4-inch *F.* 2.3.
- 1 150-mm or 6-inch *F.* 2.7.

■ 51. **STANDARD NONRECORDING CAMERA.**—The standard camera for use by assignment groups not supplied with recording equipment has an offset three-arm turret, with built-in prismatic focusing magnifier; a built-in view finder; is designed for use with 100-foot rolls on daylight loading spools or with a standard 400-foot magazine; and for 12-volt d. c. motor drive, spring drive, or hand cranking. The lens equipment consists of a 2-inch, 3-inch, 4-inch, and 6-inch lens. The tripod is of the heavy-duty type with a pan and tilt head. Five 400-foot magazines are supplied for each camera. A 12-volt d. c. motor with cables and connectors and a 12-volt storage battery comprise the power equipment. A built-in governor permits exposures at 8, 12, 16, 24, 32, and 48 frames per second. It has a standard sound motion-picture equipment sound-type aperture.

#### SECTION IV

### LABORATORY PROCEDURES

■ 52. **FUNDAMENTAL PRINCIPLES.**—Negative making is the most important step in photography. It requires, first, that the film be correctly exposed and, second, that it be developed correctly. From the satisfactory negative thus produced it is possible to secure any number of good prints or positive films and to produce duplicate negatives where necessary.

■ 53. **DEVELOPMENT OF STILL PICTURE NEGATIVES.**—*a.* The time and temperature method of negative development is standard in the Signal Corps. Correct use of this method necessitates the use of a developing solution of standard or known strength, and development for a predetermined time at a definite temperature. The standard working temperature for most developers is 65° F. Temperature lower than this should not be used because the activity of most reducing agents falls off rapidly at lower temperatures. Temperatures slightly in excess of 65° F. may be used providing the development time is reduced accordingly.

*b.* In using orthochromatic and process films which may be worked under a red safelight, the inspection method may be used although experience has shown that more uniform results can be obtained by time and temperature methods. The

great advantage of using a standard method of development is that cameramen know that all their negatives will receive identical treatment and that they must make their exposure come within the working latitude of the film. When a cameraman first begins work with a laboratory, he should make a series of negatives at different exposure times, submit them for development and, with the aid of the information and negatives received back from the laboratory, determine the correct exposure and correlate it with his future work by means of an exposure meter. For details of technique and formulas for developing negatives and prints, etc., see manuals pertaining to Basic Photography.

■ 54. DEVELOPMENT OF MOTION PICTURE NEGATIVES AND POSITIVES.—*a.* Full sensitometric control of all development of motion picture films of all types, sound as well as picture, will be used. Gammas for the various classes of work will be prescribed by the proper authority in order to secure uniformity of product. This system is a scientifically controlled time and temperature method of development and is necessary to secure the best quality and uniformity of sound and picture.

*b.* For details as to the principles of sensitometry and laboratory procedures, etc., reference should be made to the publications, "Motion Picture Laboratory Practice" and "Motion Picture Sound Recordings," and other commercial texts mentioned in paragraph 49*f* (2).

■ 55. HANDLING OF STILL PICTURE NEGATIVES AND PRINTS.—As soon as a negative is developed and dried it should be assigned a file number and placed in a negative jacket. The numerical series to be used and the method of numbering are prescribed by GHQ for all photographic units in the theater of operations. The method of numbering is such that the number will appear on the face of each print near one of the lower corners. No prints should be released from a laboratory which do not show this number in some form to facilitate identification in reordering. Instructions as to the methods of captioning prints and negative preservers and as to the disposition of file prints, master prints, negatives, etc., are prescribed by GHQ.

■ 56. METHODS OF HANDLING MOTION PICTURE NEGATIVES AND PRINTS.—*a.* In motion picture production where the mission involves the production of a film on a specific subject, a scenario is prepared in advance and a project number is assigned to that subject. Each scene in the scenario is assigned a number, starting with number 1 for the first scene, etc., throughout the scenario. Extra numbers are inserted in each sequence to permit the director to make additional scenes and keep them with the related material. The production number, scene number, take number, camera number, and date are photographed ahead of each scene made by holding a "slate" bearing this information in front of the camera and exposing from ten to twenty frames. Corresponding scene and take numbers are punched in the film ahead of each sound record.

*b.* (1) Synchronization points for corresponding picture and sound are obtained by starting the camera and recorder simultaneously while a man holding a pair of clap sticks stands in front of the camera. As soon as all elements of the system are up to speed, the clap sticks are brought together sharply and this man steps quickly out of the scene. These sticks establish synchronization points on both sound and picture negatives. Some equipments may have fogging lamps in the camera and recorder to establish the synchronization marks as soon as speed is attained.

(2) Using these synchronization points as the starting point for each scene, the laboratory runs the work prints through an edge-numbering machine which prints the scene number, take number, and the footage within the scene, starting from the zero point, every foot throughout the scene, along one edge of the film. Sound work prints have the same numbers as corresponding picture prints. This numbering system identifies every scene regardless of length after being cut and provides a quick means for synchronization of sound and picture by matching the numbers in the editing machines. The manufacturers' code numbers on negatives are also printed on the work prints. In cutting negatives to match work prints, the scene and take number appearing on one edge are used to identify the corresponding negative, and the manufacturers' code numbers are used to identify the

exact position of the portion of the scene to be used. This is to avoid any errors due to mistakes in edge numbering. All work prints must be edge numbered before any cutting or editorial work is attempted.

c. (1) On record and news type work which is made more or less on a catch-as-catch-can basis, cameramen should definitely identify each scene with the corresponding captions. If time and opportunity permit, a simplified slating system similar to that described above can be used. After the negative is developed, each scene is given a number at the laboratory which is carried through in printing and edge-numbering operations. The numbers to be used for this purpose are allotted by GHQ or other proper authority. Instructions as to the policy to be followed in cutting original negatives from such scenes into completed films are issued by the War Department or GHQ. Where a scene has considerable value or may be needed for use in more than one completed subject, duplicate negatives will be required. Master positives from which duplicate negatives are made will be made from all valuable scenes and from completed training films and similar valuable films.

(2) These master positives are made at an early stage as insurance against loss or damage of original negatives in printing operations. Master positives should never be projected and should be handled and stored with the same care as is exercised with negatives.

■ 57. DISTRIBUTION OF PRINTS.—*a.* Each motion picture laboratory is equipped to produce 35-mm silent or sound prints and 16-mm silent or sound prints by optical reduction from 35-mm negatives. The number of copies of completed films to be produced in each size and the distribution of these prints are in accordance with War Department orders or policies and in the theater of operations in accordance with instructions from GHQ.

*b.* Libraries of prints for regional circulation are established at convenient distribution centers. Requests for the loan of prints from these libraries should be addressed to the headquarters maintaining such libraries and information supplied as to the size desired (whether 16-mm or 35-mm

size) together with the date for showing or the period within which the film is to be used. Information as to the subjects available are published from time to time in War Department circulars and in the theater of operations in official lists from GHQ.

## CHAPTER 7

### SIGNAL INTELLIGENCE SERVICE

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#### SECTION I

#### GENERAL

■ 58. **DEFINITIONS.**—*a.* The term “signal intelligence” as used in this manual includes all information of the enemy obtained by radio or other electrical means, by the detection of secret inks, and by the solution of codes, ciphers, and messages. It does not include similar information obtained by sound, flash, subaqueous, or other ranging.

*b.* The term “signal security” as used in this manual is the security of friendly signal communication message traffic against the availability and intelligibility of that traffic to enemy or other intelligence agencies.

*c.* The term “signal intelligence service” as used in this manual includes all agencies and activities concerned with—

- (1) Solution of enemy codes, ciphers, and messages.
- (2) Finding positions of enemy radio and other transmitting stations.
- (3) Intercepting enemy or other signal communication for the purpose of gaining intelligence.
- (4) Preparing instructions for issue by proper authority as to measures to be taken to assure signal security.
- (5) Intercepting friendly signal communication for the purpose of discovering violations of signal security or other regulations.
- (6) Compiling, distributing, and accounting for codes, and devising cipher systems.
- (7) Training of personnel for the above activities.

■ 59. AGENCIES.—*a. Exclusive.*—The following agencies, the organization and operations of which are covered in FM 11-20, are provided exclusively for signal intelligence service purposes:

- (1) Signal intelligence service, headquarters, signal service, GHQ.
- (2) Signal intelligence service, headquarters, signal service, army.
- (3) Signal company, radio intelligence.

*b. Partial.*—Incidental to their primary operations, all units of all arms obtain and transmit signal intelligence just as they obtain and transmit all other intelligence. Signal personnel and equipment not engaged in performing their primary missions may, when ordered, be employed in all units for this purpose.

■ 60. EQUIPMENT AND SUPPLIES.—*a. Authorized.*—Except as indicated in *b* (1) (*c*) below, Table of Basic Allowances for Signal Corps specifies the equipment and supplies authorized for issue to all signal intelligence service agencies.

*b. Description and use.*—(1) The equipment used for this purpose consists primarily of—

- (*a*) Electrical equipment for the detection of signals.
  - (*b*) Cryptographic systems, instructions, and material pertaining thereto.
  - (*c*) Special cryptanalytic and secret ink detecting devices.
- (2) The description, installation, operation, and maintenance of the radio and other sets employed are covered either in Technical Manuals or in instructions books for those sets. When Technical Manuals have not been issued for a set, instruction books are parts of the set and are issued with it.
- (3) Codes include complete instructions for their use.
  - (4) Cipher devices include, as parts, suitable instruction or other books for their use, except cipher device M-94 which is completely covered in FM 24-5.
  - (5) The description and use of special cryptanalytic and secret ink detecting devices are not within the scope of this manual.

## SECTION II

## SIGNAL INTELLIGENCE PROCEDURES

■ 61. GENERAL.—*a.* Signal officers of armies and higher units, working in close cooperation with the second section of the general staff of their units and utilizing the signal intelligence services of their headquarters, assure the issue of adequate instructions for the timely collection, transmission, and evaluation of signal intelligence. These instructions are as explicit as practicable in regard to the nature of the intelligence desired, the units which are to obtain it, the channels through which it is to be transmitted, and the agency which is to evaluate it.

*b.* Signal officers of lower units, cooperating similarly, assure the prompt collection, within the capabilities of their units, of available signal intelligence, and its prompt transmission in conformity with the instructions mentioned in *a* above.

*c.* Detailed instructions as to the analysis of enemy codes and ciphers and as to the detection of secret inks are prescribed by the War Department and transmitted to those concerned when necessary.

■ 62. SOURCES OF SIGNAL INTELLIGENCE.—*a. Radio.*—Owing to its nature, radio is one of the most important sources of signal intelligence. Even if efficiently used by the enemy, the presence and approximate locations of his transmitters can be determined, and their transmissions can be intercepted and used for signal intelligence purposes; if inefficiently used, these determinations and solutions are simplified and expedited.

*b. Wire.*—In some situations, particularly in stabilized warfare, the enemy wire system is an important source of signal intelligence. Transmitted currents flow through the ground in ground return circuits, have an inductive effect in all circuits, and may in poorly constructed lines or in wet weather leak to the ground from all circuits. Such currents may be detected and the transmissions read.

*c. Other means.*—Other means of signal communication employed by the enemy may under special circumstances yield valuable information. Improperly defiladed visual sta-

tions may permit reading their signals; pyrotechnic signals can often be seen when projected; panels may be read by aircraft; and sound signals may be heard. Messengers carrying messages, codes, or ciphers may be captured; pigeons may be shot and their messages captured; and codes, cipher devices, and cipher keys may be found on casualties and prisoners or may be captured after abandonment by the enemy.

■ 63. RADIO.—For a discussion of the possibilities and limitations of radio interception and position finding, and for the procedures followed in such activities, see the operations of the radio intelligence company as given in FM 11-20.

■ 64. WIRE.—The uses of listening-in devices for intercepting wire communication are very limited, but when opposing lines are close together, such devices must be tried even if only for the purpose of signal security. Without the direct tapping of lines, the distances over which telephone conversations can be overheard by listening-in stations are comparatively short and are limited by the sensitivity of the amplifiers employed. Equipment for this purpose is made available when necessary.

### SECTION III

#### SIGNAL SECURITY PROCEDURES

■ 65. GENERAL.—For general instructions as to safeguarding military information, see AR 380-5, and for general instructions as to counterintelligence, see FM 30-25. Detailed instructions as to the procedures to be followed in the compilation, handling, accounting for, and disposition of codes, and in the preparation of cipher keys are prescribed by the War Department and transmitted to those concerned when necessary. Paragraphs 66 and 67 indicate some procedures which contribute to signal security.

■ 66. PREPARATION OF SIGNAL OPERATION INSTRUCTIONS.—All general instructions not contained in authorized codes, issued with the cipher devices, or contained in FM 24-5, governing the use of codes and ciphers by the field forces, assigning meanings to supplement code groups, and prescribing cipher keys, are published in signal operation instruc-

tions. Similar instructions contain map coordinate codes, pyrotechnic codes, assignments of frequencies, call signs, etc. For examples of such instructions, see FM 24-5. Each item so published bears the classification demanded by AR 380-5, and is given only the distribution permitted thereby. If an item must be distributed to front line units or to air elements operating over or beyond the front line, suitable instructions are included in the item as to safeguarding it from the enemy. These instructions may prohibit carrying such an item further forward than certain headquarters or may permit the carrying only of essential extracts therefrom beyond certain limits.

*a. Supplement code groups.*—In prescribing the meanings of supplement code groups, superior commanders limit subordinate commanders only to the extent demanded by the situation, the need for coordination, and the elimination of conflicts and misunderstandings. In all cases, division commanders are afforded the use of some supplement groups to meet local needs. Assigned meanings are changed only when necessary or when the codes are changed.

*b. Identification, panel code.*—In prescribing identification panel code groups, the groups are changed as often as necessary.

*c. Cipher keys.*—In prescribing cipher keys for the cipher device M-94, a cipher key is not used during operations for a period exceeding 1 day.

*d. Map coordinate codes.*—As early as gridded maps become available, the signal officer of the largest unit operating over any one area recommends the issue of a suitable map coordinate code as an item of signal operation instructions applicable to the entire area covered by those maps, and after approval assures the early and adequate distribution thereof. This code is changed only when directed by the issuing headquarters.

*e. Radio call signs.*—Radio call signs are changed at least once each week and oftener if necessary.

■ 67. EMPLOYMENT OF MEANS OF SIGNAL COMMUNICATION.—*a. General.*—From the signal security standpoint, signal officers consider the matters indicated below prior to recommending the employment of means of signal communication to their

commanders. In general, those means which are most secure are required to operate to their full capacity before a less secure means is employed, even though all less secure means available are kept in readiness for employment as needed. In most operations, considerations other than security are paramount, and security is sacrificed to some extent to meet the needs. When security becomes the paramount consideration in any operation, however, the use of insecure means is limited for the periods and to the extent demanded. Radio communication may be entirely prohibited, and the use of other means may be authorized only in urgent cases. In all cases no more power output is used than is necessary. All operating procedures are standardized, and transmissions, particularly those in connection with schedules and message handling, are kept to a minimum. Available means may be arranged in order of greatest security as follows, assuming the conditions indicated:

(1) Wire communication, assuming normal field installation and operation and no direct tapping of lines by the enemy:

(a) Buzzerphone EE-1-A.

(b) Telegraph printer.

(c) Telegraph sets TG-5, TG-5-A, and others manually operated.

(d) Telephone.

(2) Messenger communication in rear of battalion command posts.

(3) Pigeon communication, assuming normal cryptographing of messages.

(4) Lamps and flags when signals are not visible to enemy ground or balloon observers.

(5) Radio communication, assuming normal cryptographing of messages or frequently changed prearranged messages.

(6) Panel communication.

(7) Pigeon communication in the clear.

(8) Radio communication in the clear.

(9) Lamps and flags when signals are visible to enemy ground or balloon observers.

(10) Pyrotechnic and sound communication.

*b. Wire communication.*—Since necessity compels the use of wire communication generally, the following are routine signal security procedures in all operations:

(1) All wire circuits leading to areas not occupied by friendly forces are cut. If time permits, portions thereof are demolished, and ends of wires leading to hostile territory are insulated from the ground.

(2) Ground return telephone circuits are not usually employed.

(3) Telegraph equipment is adjusted for minimum current operation.

*c. Other means.*—Routine signal security procedures in messenger, pigeon, radio, visual, and sound communication are adequately covered in FM 24-5.

## CHAPTER 8

### SIGNAL COMMUNICATION

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#### SECTION I

#### GENERAL

■ 68. **DEFINITIONS.**—*a. Signal communication* comprises all methods and means employed to transmit messages and telephone conversations. It is employed by all personnel of the Army, including commanders, their staffs, liaison agents, and observers. (AR 105-15.) For the methods and technique relating to the installation, operation, and maintenance of, and planning for signal communication within the division and smaller units, see FM 24-5.

*b.* The following terms used in signal communication are defined in FM 24-5 and are given the same meanings in the 11-series of field manuals:

- (1) Message, including various classifications thereof.
- (2) Agency of signal communication.
- (3) Means of signal communication.
- (4) Command post.
- (5) Axis of signal communication.
- (6) Signal operation instructions.

(7) Various terms applying to the different agencies of signal communication.

*c. Tactics and technique* signifies collectively the general and detailed methods employed by signal troops in the performance of their assigned tasks. *Tactics* refers to the art of executing tactical movements prior to battle and of

employing combat power on the field of battle. *Technique* refers to the technique of military operations rather than to the technique of operating technical equipment. (See par. 70.)

■ 69. AGENCIES.—*a. Completely covered in other publications.*—Message centers and visual and sound communication agencies are completely covered in FM 24-5 and are not discussed further in this manual. Other agencies which may become necessary in the rear areas of the combat zone and in the communications zone primarily for administrative and warning purposes as distinguished from tactical purposes are dealt with in FM 11-20.

*b. Partially covered in other publication.*—Signal supply and messenger, pigeon, radio, and wire communication agencies are partially covered in FM 24-5, but are dealt with further in Chapter 5, and sections IV to VII of this chapter, respectively.

■ 70. PRINCIPLES.—The following general principles govern the tactics and technique of signal communication:

*a. Cooperation and coordination.*—The signal system serving each tactical unit is complete within itself and functions to meet the needs of the unit commander. It also forms an integral part of the systems of superior units. This requires close cooperation and coordination between signal systems of all units. These requirements are secured by—

(1) Thorough and uniform training for all signal units of the command;

(2) The issue of signal operation instructions coordinating the operation of each agency of signal communication and related activity sufficiently far in advance to insure complete understanding by all concerned; and

(3) Tactical and technical supervision and inspection to insure uniform practices and procedures within and between all signal and communication units.

*b. Channels of signal communication.*—The primary purpose of signal communication is to furnish the agencies whereby the commander may direct and coordinate the efforts of his command. Therefore the channels of signal communication coincide with the normal channels of command. A

violation of this principle tends toward confusion in the establishment and operation of signal systems.

*c. Extent of employment of agencies.*—The extent to which signal agencies may be employed efficiently is limited by the conditions imposed by combat and by the special characteristics of particular equipment. For example, fog may preclude the use of panels for ground-air communication, sufficient radio frequencies may not be available to permit certain radio sets of a unit to operate, and the mobility of the unit may limit wire communication or make its use impracticable. Therefore, the most efficient use of signal agencies requires that their employment be restricted to the actual requirements of conditions existing at the time. In case it appears necessary to restrict the routine employment of one or more signal agencies available to a commander, final decision as to the extent to which each is to be employed is based upon a consideration of the demands of the tactical situation and upon an analysis of the relative importance of the signal requirements of the various units of the command. The decision in this matter requires also a balance between tactical requirements and the physical limitations of the particular equipment involved.

*d. Routine procedures.*—In view of the complex characteristics of modern signal equipment, the plan of signal communication for the command must be simple and must conform to routine practices insofar as practicable in order that the system may operate with efficiency. Signal requirements of a well-trained command are far more simple and uniform than those of a command not so well trained. The elementary principles of the organization of signal communication for a given headquarters may be outlined briefly as follows:

(1) The agencies of signal communication employed must be suitable to the personnel and equipment available, the tactical distribution of headquarters on the battlefield, and their movements.

(2) A means of signal communication selected for use should—

(a) Be simple in its organization and operation to obtain efficiency.

(b) Be reliable to insure the safe delivery of messages entrusted to it.

(c) Be capable of expansion to meet changes in the situation.

(d) Have as rapid a rate of transmission as is consistent with the preceding requirements.

(3) Since the enemy endeavors to intercept messages sent in any manner, preferably those means of signal communication should be employed which insure adequate signal security. (See ch. 7.) Such means will vary with battle conditions; for example, signal lamps may be used toward the front under certain conditions of terrain which obscure the light rays from the enemy, whereas other terrain conditions may prevent their use toward the front since the signals could be intercepted as transmitted.

(4) Even when one means of signal communication is capable of handling the peak message traffic load, reliance should not be placed on this one means alone. One or more alternate means should be provided for use in case the principal means fails. This necessitates a thorough understanding of the characteristics and extent of the message traffic load and the message traffic capacity of the several means of signal communication available, as well as knowledge of the degree of signal security or lack thereof inherent in each of the several means.

*e. Teams and teamwork.*—The organization and training of signal and communication troops should be given careful consideration. Due to the fact that the activities of signal and communication troops are dispersed throughout the entire combat area of the command, such troops should be organized into self-contained working teams in accordance with the requirements of technical functions. Since the technical efficiency of signal and communication troops is of paramount importance, unit commanders are responsible that their technical training takes precedence over all other forms of training required for them. (See ch. 4.)

## SECTION II

## RESPONSIBILITY

■ 71. GENERAL.—The responsibility for signal communication is fixed in detail by AR 105-15. In general, the responsibility in the field is as shown in paragraphs 72 to 75, inclusive.

■ 72. GENERAL RESPONSIBILITY FOR FIELD SIGNAL COMMUNICATION.—*a.* The commander of each tactical unit is responsible except as noted in paragraph 73 *h* (3) for—

(1) The installation, maintenance, and operation of tactical signal communication within his own unit, and to, but not including, the headquarters or the command post of his next subordinate units, and the headquarters or command post of any units which his unit supports by fire.

(2) Establishing and maintaining communication with adjacent front line units and with front line units which his unit supports as a reserve, by means of liaison personnel, messengers, and other necessary means; and by wire communication as directed by his superior under the provisions of *b* below.

*b.* Between adjacent units, signal communication will be installed and maintained as directed by their common superior.

*c.* For further details, see paragraph 78.

■ 73. SPECIFIC RESPONSIBILITY FOR INSTALLATION, MAINTENANCE, AND OPERATION OF FIELD SIGNAL COMMUNICATION.—*a.* Infantry troops will install (except as noted in *h* (2) below), maintain, and operate all signal communication within infantry units, including unit headquarters, and the following signal communication to other units: Visual signals to initiate call for fire support; direct communication from the Infantry to the airplane; and communication with adjacent front-line units and with front-line units which they support either by fire or as a reserve. In addition, tank units will install, maintain, and operate signal communication with adjacent tank units when required.

*b.* Cavalry troops will install (except as noted in *h* (2) below), maintain, and operate all signal communication within the horse cavalry brigade, including brigade head-

quarters, within the mechanized cavalry regiment, including regimental headquarters, and in all cavalry mechanized combat vehicles, and to other units as prescribed for the Infantry.

*c.* Field artillery troops will install (except as noted in *h* (2) below), maintain, and operate all signal communication within field artillery units including unit headquarters, and the following to other units: Direct communication, including liaison detachments, to the command post of front line infantry, cavalry, or engineer units which the artillery is directed to support or to which the artillery is attached, and to artillery observation posts in advance thereof, including visual signals to relay to the artillery but not to initiate call for fire support; direct communication from the artillery to the airplane; and communication with adjacent artillery units.

*d.* Coast artillery troops will maintain and operate all signal communication and signal apparatus pertaining exclusively to the fixed harbor and fixed anti-aircraft defenses, except those which pertain to the administrative post telephone systems, and they will install, maintain, and operate the following signal communication from the fixed defenses to other units: Direct communication from the ground to the air, and communication with adjacent forces, if any. They will install (except as noted in *h* (2) below), maintain, and operate all signal communication within all mobile coast artillery units, including the unit headquarters, and from such units to other units as prescribed for field artillery troops.

*e.* Engineer troops when serving as Infantry will install, maintain, and operate all signal communication within engineer units, including engineer unit headquarters, and to other units as prescribed for infantry troops. When carrying out engineering missions they will install, maintain, and operate signal communication as prescribed for noncombatant troops. (See *g* below.)

*f.* (1) The installation of all visual, radio, and other communication apparatus in aircraft is a function of the Air Corps.

(2) Air Corps troops will—

(*a*) Operate and perform routine maintenance of all visual, radio, and other necessary communication apparatus in aircraft.

(b) Install, operate, and perform routine maintenance of all ground, radio, and visual equipment at the headquarters of all Air Corps units and agencies except such radio equipment as is used solely for administrative purposes at GHQ Air Force headquarters, wing headquarters, and base headquarters.

(3) In Air Corps units and agencies not having Signal Corps troops organically assigned thereto, Air Corps troops will—

(a) Install, maintain, and operate all signal communication at and within headquarters of such units and agencies.

(b) Install and maintain wire circuits between such Air Corps headquarters and agencies as are immediately adjacent to each other.

(c) Install, maintain, and operate direct wire communication from balloon squadrons to artillery wire nets.

g. Noncombatant troops will install, maintain, and operate all signal communication within their respective units, including their respective unit headquarters, and between their unit headquarters and detachments of the unit which may be required in addition to that established by Signal Corps and other combatant troops; and they will establish and maintain liaison with the headquarters to which the unit is assigned or attached by communication over established lines or by liaison detachments sent to those headquarters.

h. (1) Signal Corps troops will install, maintain, and operate all signal communication within the army, corps, divisions, and mechanized cavalry brigades, except as above indicated, including the headquarters message center and wire, radio, and visual communication at each of those headquarters, and signal communication with the next lower headquarters and with adjacent headquarters, and all wire and radio communication for rear installation.

(2) The Signal Corps will install authorized radio equipment in all pilot models of combat and reconnaissance vehicles of all arms and will furnish adequate instructions to the using arms for making radio installations in other than pilot models.

(3) Signal Corps troops will—

(a) Install, maintain, and operate all wire communication at GHQ Air Force headquarters, wing headquarters, and base headquarters.

(b) Install and maintain necessary wire lines between GHQ Air Force headquarters and all headquarters or agencies serving directly under GHQ Air Force headquarters, between wing headquarters and all headquarters and agencies serving directly under wing headquarters, between base headquarters and all units served by the base, and between all other Air Corps headquarters, airdromes, landing fields, and agencies not immediately adjacent to each other.

(c) Install, maintain, and operate radio sets used solely for administrative purposes at GHQ Air Force headquarters, wing headquarters, and base headquarters.

■ 74. WIRE CIRCUITS FOR MILITARY RAILWAYS.—The Corps of Engineers will arrange with the Signal Corps for the necessary wire circuits for train dispatching and for the administration of military railways, the operation of such circuits to be performed by the Corps of Engineers. The construction and maintenance of these circuits is a function of the Signal Corps. Where all the circuits along a route are turned over for the administration of military railways, the circuits will be maintained and operated by the Corps of Engineers. Wire circuits turned over to the Corps of Engineers exclusively for railway business will not be available for other purposes except by specific authority of the proper commander in each case.

■ 75. SIGNAL COMMUNICATION BETWEEN THE ARMY AND THE NAVY.—Signal communication between the Army and the Navy will be governed by approved proceedings of the Joint Board.

■ 76. RESPONSIBILITY OF TACTICAL UNIT COMMANDER.—The commander of each tactical unit is responsible for the installation, operation, and maintenance of all agencies of signal communication which form the signal system of his own unit, and for purposes of coordination he exercises supervision over the signal systems of all subordinate units of his command. For example, the division commander is responsible for the installation, operation, and maintenance of the division signal system, and for supervision over the signal systems of infantry, artillery, and other subordinate units of the division.

■ **77. SUPERVISION.**—The supervision of subordinate unit signal systems is for purposes of coordination and is dual in its nature. It includes both technical and tactical control.

*a.* The *technical* control of a signal system standardizes the technical installation, operation, and maintenance of the various agencies of signal communication of the command.

*b.* The *tactical* control of a signal system insures the establishment of the necessary signal communication at and between the tactical, supply, and administrative units and establishments, and the development of the system in accordance with the tactical plan. (See sec. III.)

■ **78. INSTALLATION, OPERATION, AND MAINTENANCE OF SIGNAL COMMUNICATION.**—*a. General.*—Signal communication is installed, operated, and maintained by the commander—

- (1) At each echelon or element of his unit headquarters.
- (2) Between echelons or elements of his unit headquarters.
- (3) From his command post to but not including the command posts of each next subordinate unit.

(4) From his command post to his observation posts, command posts of his unit reserves, landing or other air fields serving his unit, hospitals, hospital and collecting stations, reconnaissance and other security detachments operating directly under his control, depots and other supply and administrative establishments under his control, and auxiliary or attached troops and establishments as needed. (See *c* below.)

(5) Laterally between command posts of his next subordinate units.

*(a)* Lateral communication between adjacent units belonging to the same superior unit is in most cases provided for by the superior unit commander including the adjacent subordinate units in his signal system. For example, the messenger service operated by the superior unit may provide for the transmission of messages between the adjacent subordinate units, their radio sets may operate in the superior net, and lateral wire communication may be provided through the telephone central of the superior unit.

*(b)* Lateral communication between adjacent units which do not belong to the same immediate superior unit is a responsibility of the commander of the lowest common superior unit. For example, the corps commander is responsible for

lateral communication between adjacent units of adjacent divisions of the corps.

(6) For the operation and administration of the military railways under his control. (See par. 74.)

*b. Control of operation by superior unit.*—The operation of an agency of signal communication at a subordinate headquarters vital to the functioning of a similar agency at a superior headquarters is controlled by the superior unit; for example, a division radio station in the corps net.

*c. Outside of unit area.*—Frequently troops and establishments pertaining to a unit are located and operate outside of the unit area. In such cases, coordination and cooperation between superior and subordinate commanders are essential if duplication of effort is to be avoided. Some typical cases and suitable actions regarding them are indicated below.

(1) *Establishments of a subordinate unit in the area of a superior unit.*—(a) The subordinate commander requests such assistance as is necessary from the superior commander.

(b) The superior commander assists the subordinate commander by the inclusion of the establishments in the superior system or by the allocation of facilities in the superior area for the exclusive use of the subordinate commander. In the absence of this assistance, the subordinate commander meets his responsibilities without it.

(2) *Establishments of a superior unit in the area of a subordinate unit.*—(a) The superior commander includes the establishments in his system, but pending the extension of that system he may direct the subordinate commander to include the establishments in the subordinate system and allot facilities and attach troops available for the purpose to the subordinate unit.

(b) If directed to do so, the subordinate commander includes the establishments in his system. In the absence of such directions or of information that timely signal communication will be established by the superior unit, he takes this action automatically in the case of establishments in his area serving his unit.

(3) *Supply establishments serving a division.*—Establishments such as railheads, depots, and hospitals serving a division may be established by a superior commander outside

of the division area. While it is the responsibility of the superior commander to include these in the superior system, practical operation demands in many cases the temporary establishment of more direct signal communication between them and the division they serve. The superior commander may direct the division to include them in the division system or may furnish the service through his system. In the absence of instructions from the superior commander in this respect, and if the establishments are located within the division area, the division commander takes the action indicated in (2) (b) above. If located outside of the division area he may, with the assistance of the superior commander, obtain signal communication to them through the signal system of the superior unit.

(4) *Attached division aviation.*—(a) The division commander is responsible for the establishment of signal communication from the division headquarters to an attached observation squadron. When the observation squadron operates from an airdrome outside the division area, as it normally will, wire and messenger communication with the airdrome are obtained through the signal system of the next superior unit (corps).

(b) When a balloon squadron is attached to a division, the division commander is responsible for signal communication from division headquarters to the balloon squadron headquarters. In addition, he is also responsible for signal communication from division headquarters to the balloon observer (chartroom) when the latter is observing for the division and when the ascension point (chartroom) is not located at the balloon squadron headquarters. The balloon squadron commander is responsible for signal communication within the squadron and for direct wire communication from the balloon observer to the artillery units for which the latter is observing.

d. *Signal intelligence service.*—(1) The commander operates such agencies as are necessary and available for signal intelligence service purposes. For further details see chapter 7.

(2) The commander distributes such codes, ciphers, and cipher keys received for distribution from higher authority;

prepares, publishes, and distributes any additional necessary including prearranged messages; and provides for the storage and accounting for all codes issued. For further details, see chapter 10, FM 24-5, and FM 11-20.

### SECTION III

#### TACTICAL CONSIDERATIONS

■ 79. MISSION OF SIGNAL TROOPS.—The principal mission of signal troops in the theater of operations is to serve the field forces by means of an adequate and efficient signal system. Such a system is one which—

a. Is prepared to handle signal traffic at each headquarters and other establishment from the time that headquarters or establishment begins to function until it ceases operations; and

b. Permits no interruptions in the operation of the system due to movement, conditions of weather or roads, damage to installations, or unusual demands for its service.

■ 80. BASIC ESSENTIAL INFORMATION.—Although other information is necessary or desirable, the basic information indicated below is so essential to planning and operating a signal system that its absence or delayed receipt adversely affects the adequacy and efficiency of the system.

a. A knowledge on the part of the signal officer of the organization and tactics of each of the arms and services, so that, in general, the locations of the headquarters and agencies served, as well as the volume of traffic to and from those points, may be anticipated.

b. Earliest possible information of the plans of commanders, so that extensions or modifications of the signal system may be initiated in time to provide adequate service when and where needed. (See par. 12.)

c. Detailed information regarding existing signal facilities in the theater of operations, obtained prior to and during a campaign, so that full utilization may be made of those facilities.

■ 81. BASIC ADVICE TO COMMANDERS.—The signal officer advises the commander of the bearing that utilization of exist-

ing signal facilities or new construction may have upon the commander's decisions concerning the location of command posts of subordinate units or the designation of their axes of signal communication.

■ 82. BASIC OPERATION.—The following factors are essential to the operation of an adequate and efficient signal system:

a. The organization or layout of the signal system as well as the organization of signal personnel must be flexible and capable of rapid readjustment to meet the needs of a changing situation.

b. The plans of the signal officer for the establishment and operation of his own and subordinate signal systems, when approved by his commander, must be promptly disseminated for the guidance and coordination of subordinate signal and communication officers and the signal and communication personnel of the system.

c. Command post movements are habitually accomplished by preparation of a signal installation at the new location prior to the move so that continuity of service will be assured.

d. Means of signal communication must be adequate to handle peak or emergency loads, and diversified within reasonable limits. Alternate channels must be provided when possible between points where adequate signal communication is of major importance.

e. Signal traffic control is secured through message centers so that the means available may be properly used and congestion in any one of them prevented.

■ 83. ORGANIZATION OF HEADQUARTERS INTO ECHELONS.—For convenience in operation in campaign, the headquarters is usually divided on a functional basis into a forward and a rear echelon. (Par. 12 a (2).)

a. *Forward echelon.*—(1) The forward echelon of a headquarters constitutes its command post. It consists of the staff agencies immediately required by the commander for assistance in tactical operations. During such operations, the operation of the command post is continuous. The command post usually moves by bounds, and in order that signal communication with other units, especially higher headquarters, may be maintained without possible interruption during such

movement the forward echelon is divided, and a part thereof is left at the old location of the command post until the command post is established at the new location.

(2) The forward echelon often is also divided temporarily to allow certain personnel and equipment to accompany the commander to a position from which he can supervise the conduct or employment of his unit, or carry out his reconnaissance, and at the same time provide a center where pertinent information is collected and through which rapid communication with all elements of the unit is maintained. This establishment is designated as an *advance message center*. Other temporary subdivisions of the forward echelon are designated as *control points*. They are located along a route of march or within the unit's area and serve as fixed points from which staff officers can supervise tactical operations for the commander.

*b. Rear echelon.*—The rear echelon of a headquarters consists of the staff agencies not included in the forward echelon which are required for control of administrative and supply activities.

*c.* For further information, see FM 101-5.

■ 84. TRAINING.—In tracing the normal sequence of tactical operations, training is taken as the starting point as the tactical operations of any unit are successful in proportion to its degree of training. (See ch. 4.)

*a.* During the mobilization period and the time spent in rest areas, the signal officer is actively engaged not only in training his signal units but also in supervising the training of signal and communication units of the entire command. During this time, technique is practiced until it becomes routine, a common understanding as to methods and policies is fostered, and signal esprit is raised to the highest level. Tactical proficiency is developed by closing the training period with a series of tactical exercises simulating those with which the command may be confronted on the battlefield. The principle of cooperation is applied during the training period as well as in combat.

*b.* Coordinating instructions (signal operation and other instructions) are issued early in the training period. (See FM 24-5.) The signal units are trained in their use during the

training period. The items of signal operation instructions are changed from time to time during the training period to accustom personnel to such changes as will occur during active operation. Instruction in the use of signal operation instructions is so conducted that the transition from training to combat is made without confusion.

c. In the training area or in the rest area the headquarters may be divided and operated in two distinct echelons or both may be operated at one location. In either case the signal and communication units, in addition to their own training, may be called upon to furnish signal communication within echelons of the command, between echelons, and between headquarters and the major subordinate units.

■ 85. DISPOSITION OF SIGNAL TROOPS.—*a. Division.*—(1) The division in a march to combat may march in one, two, or more columns depending upon its mission and the terrain. A march in one column facilitates maneuver, and a march in more than one column facilitates deployment and supply. The march order prescribes the composition, route of march, and commander of each column. It may also prescribe an axis of signal communication (par. 90) for the march. On the march, as in combat, the command post moves by bounds; that is, the command post continues in operation at its old location until it is established in a new location. When combat is imminent, the commander and part of his staff march near the head of the main column (usually in the space between the advance guard and the head of the main body of the column following the march axis). As the situation develops, the commander makes his reconnaissance, issues instructions to the security forces, formulates his plan of action, and issues the necessary orders for the development and employment of the unit. This procedure has a deciding influence on the disposition of signal troops. The division signal company or troop must be so disposed that—

(a) Signal communication is furnished at the initial locations of the forward and rear echelons of the headquarters, between the command post and higher headquarters, and between the command post and the marching column(s).

(b) Signal communication is furnished from the commander to the marching columns, within the axial column, to

aerial and ground reconnaissance troops, and to the security force.

(c) Sufficient personnel, equipment, and transportation are immediately available with the commander to install, operate, and maintain the initial signal system in the event of deployment for combat.

(2) To meet the above requirements the signal troops move by echelon as follows:

(a) The first echelon, consisting of the signal company or troop, less detachments, with the necessary transportation and equipment, marches near the commander.

(b) The second echelon consists of detachments of the signal company or troop not included in the first echelon. These detachments continue the operation of signal agencies at the command post and rear echelon until the command post and rear echelon change. At this time, or as soon thereafter as ordered, they are moved forward to the new locations of the command post and rear echelon. Part of this echelon is usually required to continue the operation of signal agencies at the rear echelon or to move with it, as the case may be. Upon the arrival at the new location of the command post, the second echelon is employed in the installation and operation of additional signal agencies. This echelon normally takes over the operation and maintenance of the signal system, relieving the first echelon which is again used to extend the system and provide for the next displacement of the command post.

(3) The signal officer accompanies the commander (or his representative). In this position he is in close touch with the first echelon of the signal units, is able to make his reconnaissance (par. 86b) quickly, and is available to make recommendations to the commander and staff in connection with the tactical control of signal communication for any action that may develop.

*b. Larger units.*—In larger units the disposition of signal troops is similar to that for a division (*a* above) but differs therefrom in some respects. Larger units usually march in more than one column, and commanders and their staffs usually move by bounds as do their command posts. The disposition indicated in *a* (2) above applies in larger units

only to signal troops engaged in signal communication. For further details, see FM 11-20. Signal units other than those engaged in signal communication, such as photographic and depot companies, are disposed of as are service units of other arms and services so as best to perform their missions.

■ 86. RECONNAISSANCE.—*a.* The signal officer is informed concerning the existing signal facilities in the area over which his unit operates. This information may be furnished to the unit by higher headquarters, in which case it is secured from commercial telephone and telegraph companies if the operations are in friendly territory. If the operations are in hostile territory, it is secured from data obtained prior to war and from signal reconnaissance detachments who are attached to the cavalry reconnaissance and screening force for this purpose. In any case, information received is supplemented by the personal reconnaissance of the signal officer or his assistants. Through his own tactical knowledge and his contact with the staff, he keeps himself constantly informed as to the tactical developments concerning his unit. He, like all commanders, is constantly estimating the situation and arriving at decisions as to the best method of employment of signal communication for all possible situations as they unfold.

*b.* When contact with the enemy is gained by a division, the commander goes forward on his personal reconnaissance accompanied by the signal officer and other staff officers. On this reconnaissance, the signal officer secures detailed information concerning the existing signal facilities in the area, and studies the terrain with particular attention to the road net and cover. He usually leaves the commander to secure detailed information in which he is particularly interested. After his reconnaissance the signal officer rejoins the commander and secures information concerning the details of the tactical plan. He then estimates the situation and arrives at a decision.

■ 87. PLAN OF SIGNAL COMMUNICATION.—*a.* The commander of a unit, having arrived at a decision as to the action to be taken to meet a situation, evolves a plan to put his decision into effect. The plan includes the mission to be accomplished

by the force as a whole and by each element thereof. Field orders are used to announce to the command the details of the plan.

b. The tactical plan for each military operation includes a scheme of command. The signal officer must be prepared to submit recommendations relative to this scheme of command which will insure adequate control and prompt transmission of information, that is, a plan of signal communication. These recommendations include the instructions to be contained in paragraph 5 of the field orders and other pertinent matters relative to signal communication which, when approved, serve as the basis for the preparation of signal orders for the unit. In trained units it is not necessary to include routine matters. For further details, see FM 24-5.

■ 88. LOCATION OF COMMAND POSTS IN GENERAL.—The scheme of command includes the proper location of the various commanders and their staffs to facilitate the exercise of control over their troops, that is, the location of command posts. Control is practically lost if the commander is unable to communicate with his subordinate commanders. For this reason the speed with which signal communication can be established and the ease with which it can be maintained are important considerations in locating command posts. The command post is the place where the staff does its work and where contact with the commander can always be secured. All means of signal communication center there and are available for communication with subordinate, superior, and adjacent commanders.

a. *Recommendations.*—The signal officer is habitually consulted, and his recommendations are given great weight, before the location of the command post or the points on the axis of signal communication (par. 90) are decided upon. For similar reasons, the commander of a subordinate unit should be consulted whenever practicable before his command post and axis of signal communication locations are prescribed.

b. *Considerations regarding signal communication.*—Although considerations regarding signal communication may not be deemed controlling by a commander in locating com-

mand posts, they are given due weight by the signal officer before making his recommendations. The most important of these are shown below and their relative importance in any situation depends upon the extent to which dependence is to be placed in an operation on the various means of signal communication listed. Distances between command posts of various units are covered in detail in FM 11-10, 11-15, and 11-20. If distances are much greater than those indicated therein, the maintenance of signal communication will be rendered increasingly difficult, and contact may be lost with forward elements.

(1) *Messenger communication.*—Messengers usually follow roads, particularly at night, and direct routes to the front and rear from the command post expedite their movement. Other reasons for a location on or near a road are that signal and other vehicles operate to and from a command post, and commanders and their staffs visit it. A suitable and readily accessible space for a message-dropping and pick-up field facilitates the transmission of messages in this manner. (See (4) (b) below.)

(2) *Radio communication.*—Electrical power generating, switching, and transformer stations and power lines adversely affect radio communication. High frequency sets are similarly affected by most man-made structures and by natural eminences. All are avoided as much as possible.

(3) *Visual communication.*—Visibility of visual signals by friendly forces is essential, and their invisibility by the enemy is desirable, particularly in lamp, flag, and panel communication. Careful selection of locations may permit secure two-way lamp communication and greatly assist observers in receiving panel messages. Height of site is most important for projecting and observing pyrotechnics.

(4) *Wire communication.*—(a) Existing wire lines, including field wire, open wire, and cable, wire centrals, test stations, and other installations, whether constructed by civilian or military personnel, greatly reduce the time and labor necessary for the installation of wire communication. If, as is frequently the case, primary dependence is to be placed upon this means, a location which permits the use of such

facilities is most desirable. Information as to such facilities is obtained by reconnaissance (par. 86) and from records. (See sec. VII.)

(b) The location should favor control of the main effort of the unit. Since in the ordinary case greater time and labor are required for construction than for maintenance, since an existing line can be maintained by the personnel which would be used otherwise for construction, and since existing lines usually have better transmission capabilities than do field lines, this requirement can be met better by using existing facilities even if the location is not geographically nearer the main effort than by selecting a nearer location and constructing new lines. A nearer location does, however, materially assist messenger communication.

(c) If suitable locations are available near the center of the zone of action of a unit, such a location equalizes the assurance of continuity in wire communication to subordinate units on both flanks since the length of lines crossing the zone of action is about equal to each. However, the considerations in (a) and (b) above are given greater weight than is this one.

c. *Other considerations.*—(1) *Cover.*—There should be cover from hostile aerial and ground observation and fire. These conditions are best secured in divisions and lower units by selecting a location in a ravine or along a stream where there are some trees, or in a wooded area, preferably one defiladed from hostile fire. However, when operating against an enemy employing chemical agents it is necessary to consider the effects of weather and terrain on the gases and to select a location affording the maximum protection. Artificial camouflage is often resorted to for concealment from aerial observation. The distances between corps and army command posts and the front line usually are sufficient to afford protection from hostile artillery fire except from heavier caliber artillery. Since division and lower command posts are frequently located within the range of hostile artillery, complete defilade from its fire may not always be practicable. Nevertheless, a location should be sought which will assure as much protection from hostile fire as possible.

(2) *Shelter*.—Protection from the weather is desirable for a division command post and is necessary for a corps or army command post. This usually is secured by the utilization of existing buildings. Corps and army command posts are generally located in towns or cities along existing wire lines where advantage can be taken of existing signal facilities. Small villages are suitable locations for division command posts provided they are so located that the terrain furnishes cover. Since tentage is provided, the required shelter can always be secured, and the use of buildings is not of primary importance in a division although such use frequently expedites the installation of command post activities and helps to conceal the presence of the headquarters.

■ 89. TIME OF ESTABLISHMENT OF COMMAND POSTS.—Units normally establish their command posts in the prescribed locations as soon as possible after information as to these locations has been obtained. In certain situations where command posts are to be established in a given location at some later time, such as a march which is to be completed without interference from the enemy, or movements into attack positions under cover of darkness preliminary to a daylight attack, coordination requires that the hour command posts are to be established in the new locations be prescribed in the commander's field orders. As the signal officer submits recommendations for the locations of these command posts and their hour of opening in the new locations, it is necessary that he be familiar with the factors to be considered in determining this hour. These factors are as follows:

a. The time and space factors separating the signal troops from their new command post locations.

b. The time required for the installation of signal agencies after reaching the new command post locations.

c. The time required to complete the wire installation of the higher unit to the new command post location of the lower unit.

d. The practicability of signal units preceding their organizations to the new locations of their respective command posts; that is, whether the presence of covering forces between new locations of command posts and the enemy would provide the necessary protection for this purpose.

*e.* The desirability of having all electrical means of signal communication installed and ready for use at the earliest practicable hour.

*f.* For the time of movement of command posts, see paragraph 90 *d.*

■ 90. LOCATION OF POINTS ON THE AXIS OF SIGNAL COMMUNICATION.—The axis of signal communication of a unit is designated by naming the initial location of the command post and successive points to which it appears probable the command post will move.

*a.* There is no exact or normal distance that can be prescribed for the movement of a command post, since the distance it may move is controlled by the terrain and the tactical maneuver, including the rate of advance or withdrawal which may vary within wide limits. In general, the location of the command post of a superior unit should always be within a distance from the command posts of the next subordinate units that will permit the exercising of proper control and the operation of the required signal communication. Thus, if the uninterrupted advance of subordinate units continues, command posts must displace in order not to lose this control or signal communication. Again, it may be desirable temporarily to halt the advance in order to effect reorganization of troops in contact with the enemy, and in these cases the required control can be best exercised if the command posts of the units are displaced so as to locate the commanders in close proximity to their subordinates. Usually, the terrain determines the rate of advance and the limits of advance without reorganization. The troop action must be visualized and the terrain features affecting the action determined, and from these the probable future location of command posts selected.

*b.* The depth to which an axis of signal communication should extend into the enemy's position is quite variable. The axis should extend to the final objective for the operation planned. The last point named on the axis should be the location that it is estimated the command post will reach. In a limited objective attack, where subordinate units are ordered to reach and secure a certain line, the last points named on the superior and subordinate axes should be loca-

tions which are suitable for their respective command posts for the occupation, organization, and defense of the position. If there is no limit to the depth of the attack and the troops are to go as far as they can, it is much better to designate the axes to points which the command posts will, in all probability, not reach than it is to have the axes fall short of the actual advance made.

c. In the attack, the axis should be oriented conveniently with respect to the direction of the main attack or principal effort. Signal communication is often facilitated by having the axis of the superior unit follow the axis of the subordinate unit making the main attack or principal effort. When a subordinate unit is directed to maneuver around the flank of an enemy, it is often impracticable to designate an axis of signal communication for this unit. In such situations, an initial command post is designated, and the subordinate unit selects subsequent locations and makes early report of any movement of the command post contemplated.

d. Unless early information of the movements of command posts is furnished to signal units, the difficulty of maintaining signal communication is increased. Usually the signal officer is the only member of the staff familiar with the status of signal communication. Therefore, he should be consulted before the command post is moved. Failure to do so may mean considerable delay in establishing signal communication with subordinates. However, the decision as to when to move a command post is a command decision and is determined not only upon availability of signal communication at the new location, but also upon the work of the commander and his staff at the moment. It is timed so as not to interfere with the work of the staff during critical periods. For example, a division staff engaged in drawing up plans for the reorganization of its subordinate units preparatory to a continuation of the attack should not be disturbed by a displacement of the command post. Ordinarily, the command post should be moved after the staff has completed its plans or prior thereto. In the final analysis, plans for the time of displacement of the command post require careful coordination. The situation may demand that the commander and certain staff officers proceed to the new location while the bulk of the staff

remains temporarily at the old location. In such situations, the establishment at the new location may operate as an advance message center pending the arrival of the remaining elements of the forward echelon.

e. The foregoing considerations regarding the axis of signal communication in an advance apply with obvious differences to a retrograde movement. In a stabilized situation with no movement of command posts contemplated, the designation of an axis of signal communication is omitted.

■ 91. ORDERS, RECORDS, AND REPORTS.—See FM 24-5 and 101-5.

#### SECTION IV

#### MESSENGER COMMUNICATION

■ 92. BRIGADES AND LOWER UNITS.—The selection and training of messengers and the employment of messenger communication are covered in detail in FM 24-5 which may be considered complete in this respect as far as brigades and lower units are concerned.

■ 93. DIVISIONS AND HIGHER UNITS.—Due to the increased message traffic load placed upon messenger communication at division and higher headquarters, considerations in addition to those given in FM 24-5 are necessary if the signal officer is to organize and operate this means efficiently. Since scheduled messengers can handle more messages per messenger than can special messengers, and since locations of higher headquarters and of their establishments are fixed for longer periods of time than are those of lower units, the importance of scheduled service increases at division and higher headquarters. Consequently, in determining the service to be provided, detailed consideration of the following is demanded:

a. *Message traffic load which can be handled best by messengers.* With the establishment of regular and frequent scheduled messenger service, the load on other means may be reduced, particularly that incident to routine administrative and supply operations.

b. *Number of messengers available and their training.* Liberal allowances of casualties in the total initially available are necessary to avoid disruption of schedules by lack of personnel.

*c. Transportation available and its condition.* Any means of transport available in the signal units or which can be made available by the commander to increase speed of delivery or reduce the work of the messenger is desirable. Excellent maintenance of that available and the availability of a reserve are essential.

*d. Periods of message traffic peak load and the periods of maximum activity in headquarters and establishments.* Peak loads may demand more frequent schedules for short periods, and messages should arrive at destinations at times when prompt and effective action can be taken on them. If a rear establishment operates normally only during daylight hours, for example, the use of the deferred classification may materially reduce peak loads without detriment to its operations. The delivery of such messages before the opening hour of operations each day, however, becomes highly essential.

*e. Schedules of messengers from other headquarters and establishments.* Coordination with higher, lower, and adjacent signal officers is necessary to reduce schedules of each and to assure that messengers carry return loads.

*f. Routes, their condition, congestion, and distances.* Shortest distances do not always mean speediest deliveries.

*g. Schedules of railways, boats, or airplanes, if any are regularly scheduled.* Regular schedules of transport are necessary for other than signal activities, and their utilization may economize on purely signal transportation and personnel.

*h. Schedules of arrival and departure of military railway, motor, or air mail.* Coordination is necessary to avoid duplication, and if regular mail service can partially meet the needs of an establishment, less frequent schedules of messengers to it may be sufficient.

*i. Movements of headquarters and establishments or their expansion or contraction.* Frequent study and revision of established schedules are necessary to meet the needs of a changing situation.

## SECTION V

### PIGEON COMMUNICATION

■ 94. GENERAL.—All information and instructions necessary for using units to receive, care for, and employ pigeons are

contained in FM 24-5. That manual also gives the general capabilities and limitations of pigeon communication.

■ 95. **THE HOMING PIGEON.**—Complete information as to the homing pigeon, its characteristics and diseases, and instructions as to its receipt, care, handling, and treatment are contained in \*TM 11-410. Those regulations contain information and instructions applicable to field pigeon units as well as to pigeon units in the zone of the interior, and completely cover the training of pigeons.

■ 96. **ORGANIZATION AND OPERATIONS OF THE PIGEON COMPANY.**—For the detailed organization and operations of the pigeon company, see FM 11-20.

■ 97. **ADDITIONAL EMPLOYMENT.**—*a.* In order that pigeon communication may be available to combat units at the most critical times when all other means of signal communication have failed, every opportunity is taken by signal officers of all units to obtain and use pigeons in training and in operations even though the occasion of their greatest utility may never arise.

*b.* In addition to the distribution of lofts and pigeons referred to in paragraphs 98 and 99, the plan for the employment of pigeon communication includes procedures to be followed in the delivery of messages received at lofts, such special instructions as may be desirable relative to the use of codes and ciphers for cryptographing pigeon messages (see FM 24-5), the transmission of a duplicate copy of a message previously sent with the next pigeon released, the acknowledgment by other means of the receipt of pigeon messages, etc.

■ 98. **DISTRIBUTION AND LOCATION OF LOFTS.**—*a.* All available lofts are established at the earliest practicable time, fixed lofts are located so that they may best train their pigeons and supply mobile lofts, and mobile lofts are located so that they can most quickly settle their pigeons, distribute them to combat units, and transmit messages received at those lofts. Due to their frequent movement in combat, corps and divisions are not assigned lofts as a matter of routine, but having decided to establish lofts, the army signal officer attaches those lofts to or detaches them from such corps or divisions

\*See Appendix.

as may be suitable, being sure that as the troops move forward or to the rear some mobile lofts are being moved and settled in locations conforming to troop movements. In stabilized situations these attachments and locations become more permanent. Except in special cases, lofts are not attached to units smaller than a division.

b. When an order is issued attaching a loft to a corps, division, or other unit, the pigeonier in charge thereof reports by telephone or otherwise to the signal officer of such unit for instructions.

c. When a loft is established, it is necessary to select a suitable location for it. The loft is located as close as practicable to the headquarters which will receive most of its messages but outside shelled areas and within easy access of a road. It should not be located near road intersections, firing batteries, and ammunition dumps on account of danger from artillery fire.

d. The signal officer arranges to furnish telephone communication to the loft. He also provides messenger service so that the messages received at the loft can be taken to the message center. If a message taken from a bird arriving at a loft cannot be promptly delivered by messenger to the message center, it is transmitted over the telephone by the pigeonier to the message center at the headquarters to which the loft is attached. The message center at that headquarters is responsible for forwarding the message to the addressee.

■ 99. DISTRIBUTION OF PIGEONS.—a. Lofts are stocked with either day or night flying pigeons. Pigeons that are trained to fly during daylight are not suitable for use at night, and the employment of night flying pigeons during daylight will usually make such birds unsuited for future night flying.

b. When a mobile loft, including its personnel, has been attached to a corps or a division, the signal officer thereof includes in his plan of signal communication provisions for the distribution of the pigeons to designated combat units. In general, pigeons are not usually released at corps or infantry division headquarters but only by units below the division and possibly by the cavalry division headquarters. In the usual case, the signal officer considers the distribution of pigeons as a signal supply matter and utilizes the supply

agency of his headquarters, assisted by the attached loft personnel, to make this distribution and the collection of empty baskets or other equipment thereafter.

c. When a mobile loft has not been attached to a corps or a division, the army signal officer similarly provides for the distribution of available pigeons to the corps or division headquarters for further distribution by such headquarters to lower units. In this case, loft personnel accompanies the pigeons to such headquarters, and unless directed otherwise by the army signal officer assists in the further distribution directed by the corps or division signal officer.

d. Since pigeons should not be kept away from their lofts for a longer period than 2 days and 3 nights, they are issued to the designated units at as short a time as possible before their probable employment.

e. The personnel which delivers pigeons to combat units may make such deliveries at night. In such cases, the pigeoneer baskets the pigeons as late as possible before the transportation is to call for them. He sees that the birds going to each headquarters are put in separate baskets and that the baskets are plainly tagged.

f. Pigeons are delivered to the message center of the unit concerned, the personnel of which are trained in the care and handling of the birds. In special situations they may be issued to individual officers, combat vehicles, or small units. As opportunities present themselves, delivering personnel inform receiving personnel of proper methods of caring for and handling pigeons so as to overcome deficiencies of releasing personnel in this respect.

g. In spite of every precaution, a number of birds are sure to be lost when they are used. It is necessary that mobile lofts be kept supplied with young birds far enough in advance in order that the loft will have sufficient time to settle and train them properly before they are used.

## SECTION VI

### RADIO COMMUNICATION

■ 100. SCOPE.—*a.* The purpose of this section is to cover the control and supervision of all radio communication within

the areas occupied or controlled by large units and the furnishing of special radio services for large commands.

b. The method of establishing radio nets, the operating procedures for use in these nets, and the keeping of station records are completely covered in FM 24-5. Radio communication in divisions and higher units conforms to the method and procedures indicated therein.

c. Terms used in radio communication and defined in FM 24-5 are given the same meanings in this manual.

■ 101. CHARACTERISTICS AND USE.—*a. Field radio sets.*—In their present state of development field radio sets are characterized by certain advantages as well as disadvantages.

(1) *Advantages.*—(a) Rapidity of installation.

(b) Facility in establishing communication with moving units.

(c) Facility in broadcasting urgent information of great interest.

(2) *Disadvantages.*—(a) Low traffic capacity.

(b) Low degree of signal security.

(c) Liability to interruption due to interference.

*b. Employment of radio communication in units above the division.*—Due to the foregoing characteristics, radio communication in units larger than the division is considered only an emergency means between fixed ground stations. Between such elements as aircraft, mechanized forces, distant cavalry forces, naval and other vessels, and the appropriate ground and other headquarters with which contact is necessary, radio communication becomes the principal and often the only means.

*c. Location of radio stations.*—(1) *General.*—Radio stations should be, in general, sufficiently removed from the headquarters or establishment which they serve to prevent long range artillery fire, or hostile aerial bombardment directed at the radio stations as a result of hostile position finding determinations, from falling on the headquarters or establishment. (See par. 106a.) At the same time the stations must not be so far removed as to restrict unduly the movement of such traffic as those stations must handle.

(2) *Effects of location on distance range.*—(a) *Hills.*—Although highly desirable from a tactical standpoint, stations

located directly in rear of hills, particularly high ones, cannot be expected to work normal distances. Sets having a normal range of 30 miles over rolling, flat, or slightly hilly terrain often suffer a decrease of 15 miles of range when the set, particularly the transmitter, is located in a position such that the wave is obliged to travel over a hill two or more times as high as the antenna of the set. The nearer the antenna to the base of a high hill, the greater will be the decrease in range.

(b) *Trees.*—Sets located under trees or dense brush may also fail to work the normal distance. Foliage absorbs radiation. The extent of this absorption depends principally upon the nearness of the foliage to the antenna and the kind of foliage, dense foliage being more detrimental than thin. The functioning of a receiver does not suffer from the proximity of foliage as much as does a transmitter.

(c) *Power and other wire lines.*—While no set should be located in a position such that its antenna must be erected directly under power or other wire lines, reasonable proximity to such lines is permissible except when working in high frequencies. High-frequency radiation is adversely affected by close proximity of antennas to power or similar lines and to other large metal structures.

d. *Effect of movement on distance range.*—In general, a vehicular or pack set has a greater distance range when halted; a pack set has a greater distance range when removed from the pack animal; and an airplane set, if capable of operating in flight and when landed, has a greater distance range when in flight.

■ 102. CLASSIFICATION OF RADIO ACTIVITIES.—Radio activities in the theater of operations fall under the following general classes:

a. Military, including the transmission of messages, the collection of signal intelligence, and aids to air navigation.

(1) Radio intelligence activities, being primarily concerned with the signal intelligence service rather than with signal communication, are discussed in chapter 7 and in FM 11-20.

(2) For radio aids to air navigation, see paragraph 7a (1).

b. Civil, both commercial and private.

■ 103. CONTROL AND SUPERVISION OF MILITARY SYSTEMS.—The signal system in the theater of operations may include over 300 radio nets, the operation of such a number without serious interference requiring the highest order of supervision and control. These are effected by—

a. Assigning call signs to all radio stations in the theater of operations. (See par. 104.)

b. Assigning, as nearly as practicable, noninterfering operating frequencies to the various nets and, if necessary, silencing certain nets in order that others having more important traffic may operate. (See par. 105.)

c. Supervising the operation of nets to insure the observance of orders and regulations. (See FM 11-20.)

■ 104. ASSIGNING CALL SIGNS.—The procedure prescribed for the preparation of signal operation instructions assigning call signs is as follows:

a. *By whom prescribed.*—(1) The commander of each unit larger than a division prescribes the net call signs for each of the radio nets pertaining to and controlled by his headquarters, and the call sign for each of the subordinate headquarters and detached stations included in those nets. He directs the commanders of his next subordinate units to do likewise for their nets and subordinate units.

(2) Ordinarily, the division commander prescribes net and station call signs for use throughout his division except at his own headquarters, so as to simplify calling during internet traffic within the division. However, if conditions arise making it advisable to delegate such authority to his next subordinate commanders, he is authorized to do so. The same principle applies to corps, army, and GHQ commanders in assigning call signs to their respective corps troops, army troops, and GHQ aviation and reserve units.

b. *Precautions for clarity.*—(1) One call sign is assigned to a headquarters or establishment, but not one to each of its radio stations; all of the stations at any one use the same call sign.

(2) A commander whose headquarters has a station in a superior net does not assign the call sign of his own headquarters; he merely repeats the call sign assigned to it by the superior commander.

(3) When any headquarters operates a radio station not located at those headquarters, as at a rear echelon, an advance message center, or with small combat units, the call sign of each such distant station may be the call sign of the headquarters to which it pertains followed by an identifying letter or number assigned by such headquarters. These call signs are made known by the assigning headquarters to all stations with which each such station is to operate.

(4) Two-letter call signs with or without numerals are generally used for field operations. Letter combinations which give an unduly large number of successive dots or dashes, such as HH and OO, or which represent commonly used abbreviations or procedure signals, such as GR, AB, and AA, are avoided.

*c. Precautions for signal security.*—(1) As a means of preserving secrecy as to movements or reliefs of units, relieving units take over with the least practicable change the call signs of the relieved units.

(2) Whenever assigning or changing call signs for certain areas or organizations, care is taken to adopt a method (or rather a lack of discernible system) which will make it difficult for an enemy to determine our tactical areas or organization by noting definite areas in which our call signs have definite characteristics different from those of other areas, or in which call signs change at times different from the times of change in other areas or organizations.

(3) Signal operation instructions assigning call signs include a suitable prohibition against taking them forward of the command posts of front-line battalions, except for such few extracts as are required by aerial observers and others. For an example, see FM 24-5.

■ 105. ASSIGNING FREQUENCIES—*a. General procedure.*—Each radio net in the theater of operations is assigned in signal operation instructions a frequency channel on which each station of that net must operate. For point-to-point operation, when the volume of traffic requires duplex operation, the station at each point is assigned a different frequency. The procedure in such cases conforms in general to that indicated herein for the assignment of specific frequencies for

nets. In view of the inevitable confusion resulting from a lack of strict frequency control when many radio channels are being used in a relatively small area, the superior headquarters in a theater of operations exercises close supervision over the frequency assignments for the entire theater. The superior unit in the theater assigns a specific frequency to each net under its direct control, and allots to each major subordinate unit a group or block of specific frequencies for assignment to the nets within that subordinate unit. This group must be such that the subordinate unit can assign from the group to each of its nets a frequency which is within the frequency range of all types of radio sets used in that net. The subordinate unit, having received an allotment of such a group, assigns a definite frequency for each net under its direct control, and in turn suballots to its major subordinate units groups of specific frequencies. Usually the division does not suballot groups of frequencies but assigns a particular frequency to each net within the division.

*b. Basic considerations for prevention of interference.*— Certain basic factors must be considered in allotting specific frequencies from the frequency ranges of the various radio sets if a minimum of interference is to be achieved. The ideal assignment of frequencies is one which will permit each set to operate on its assigned frequency and yet not cause interference with any other set even if the former operates on the assigned frequency of the latter. The band of frequencies (channel width) over which a given transmitter may cause interference depends on the following factors:

(1) Distance between transmitter and receiver; the greater the distance, the narrower the interference band.

(2) Power of the transmitter as indicated by the effective transmitting distance range of the set.

(3) Type of transmission used, that is, cw, voice, or tone. A given transmitter usually has the narrowest interference band when operated on cw and a wider interference band on tone or voice.

(4) Frequency used. Generally speaking, the higher the frequency used the wider will be the interference band, and the greater should be the frequency separation between sets operating within their rated distance range of each other.

(5) Frequency stability of the transmitter. To be considered with this factor is the initial accuracy of the transmitter frequency setting, and the frequency drift after the transmitter is once calibrated and set on a particular frequency.

(6) Characteristics of the receiver with which the transmitter is apt to interfere, including particularly sensitivity and selectivity.

(7) Dimensions of the receiving antenna system.

*c. General guide for initial assignments.*—The data presented below are a general guide only for assigning initial frequencies, and adjustments will probably be necessary later to correct individual cases of interference. Frequencies used by the enemy and by other governmental or commercial agencies, and harmonics of these frequencies and of those used by our own transmitters, may make necessary a readjustment of assignments of frequencies to military radio nets. The initial assignment of a frequency to a net, the sets of which are to operate within interference range of sets in other nets, should be such that—

(1) The separation between adjacent assigned frequencies is 20 kc. for cw transmitters which have a distance range of 5 to 15 miles and a frequency range in the band from 2,300 to 5,100 kc.

(2) The separation between adjacent assigned frequencies is 500 kc. ( $\frac{1}{2}$  mc.) for voice transmitters which have a distance range of 5 to 10 miles and a frequency range in the band from 25 to 70 mc.

(3) The separation between adjacent assigned frequencies is preferably 1 percent of the highest frequency and never less than 20 kc. for transmitters other than those in (1) and (2) above.

(4) The separation between frequencies assigned to different nets, each of which has a station located at the same headquarters or in the same general locality, is at least twice and preferably four times the separation indicated in (1), (2), and (3) above.

*d. Procedure when overlapping or duplication of channels is required.*—In armies and larger units, the next subordinate

units will, in general, require for their normal net operation all of the available channels on most if not all of their sets. When this is the case, the entire frequency bands of such sets may be allotted to each subordinate unit without restriction, provided all of each unit's sets are beyond the distance range of any of the sets of the other units. If, however, the distance between subordinate units is less than the distance range of the sets for which duplication of all available channels is required, the reallocation of frequencies by the subordinate unit should be restricted by the superior unit in such a way as to reduce to a minimum the possibility of serious interference. Methods which may be used to accomplish this result are indicated below.

(1) When the subordinate units are adjacent, and the frontage of each exceeds the normal distance range of the sets for which channels must be duplicated, the allotment of the entire frequency band of such sets by the superior unit is accompanied by the specific direction that frequencies will be reallocated or assigned in such a manner that they increase progressively from one flank to the other in a specified direction.

(2) In very congested areas, and when subordinate units have very narrow frontages, the restriction indicated in (1) above will, in general, be insufficient to minimize interference. In this case the reallocation or assignment by the subordinate unit is restricted further. Instead of assigning the entire frequency band, as indicated in (1) above, specific frequencies are assigned. Adjacent frequencies assigned to the first subordinate unit are separated as indicated in c above, and a total number of frequencies is assigned so as to cover completely the frequency range of the transmitter. The assignment of specific frequencies to the other subordinate units is made in the same manner, except that the separation between any frequency assigned to one unit and any assigned to another is the maximum possible consistent with the number of units which must be allowed use of the entire range of the set.

For example, the assignments of frequencies to three divisions for the radio set SCR-161 might be: 4,370 kc., 4,390 kc., and 4,410 kc. to the first division; 4,376 kc., 4,396 kc., and 4,416

kc. to the second; and 4,383 kc., 4,403 kc., and 4,423 kc. to the third.

(3) At times it will be impossible to prevent interference sufficiently to permit all nets of a unit to operate. In such cases, it is necessary to silence all or a portion of the nets of certain designated units. When for interference reasons it becomes necessary to limit the number of radio nets operating in any unit, preference for operation is given to nets and stations in the following priority:

(a) Nets for command purposes between airplanes, and for command, reconnaissance, and fire control purposes between air and ground.

(b) Between horse Cavalry and mechanized units sent out some distance to the front or flank for reconnaissance or other purposes and the headquarters with which they are to communicate.

(c) Between Infantry and Field Artillery for artillery liaison.

(d) From and to front line battalions when wire lines have been cut and the intervening terrain is being shelled to such an extent as to make the use of runners impracticable.

(e) Between units larger than a battalion when wire and messenger communication are impracticable.

(4) When a shortage of clear channels exists, the superior unit may allot to each major subordinate unit only a portion of the frequency channels required for operation of all radio nets within that unit. Having received an insufficient number of channels for normal operation of all of its radio nets, the subordinate unit may assign frequencies on a priority basis as indicated in (3) above, or may assign frequencies to nets when and as needed with the restriction that control of these frequencies will revert at a specific time or upon completion of a specific mission or operation. This latter method is particularly suited for large field artillery commands.

(5) Any specific situation will require, in general, a combination of the restrictions indicated above. No one method will serve to eliminate all interference problems, and even with the most adroit combination of restrictions constant revision and correction will be required if satisfactory use of radio communication is to be maintained.

*e. Data required for making initial frequency assignments.*—In order to assign frequencies, the data indicated below should be assembled by the officer or section charged with this duty. A satisfactory form for assembling some of these data is shown in section III, chapter 9.

(1) Charts showing all normal nets within the command and the sets employed in each.

(2) Frequency range of all sets employed within these nets, assembled in chart form to show channel widths of each set and the frequency overlap between different sets.

(3) Distance range of all sets employed within these nets, preferably arranged on the same chart as the data listed in (2) above.

(4) Data, as complete as is possible in view of the early stage of operations at which initial assignments must be made, on the actual location on the ground of the various radio nets within the command. These data are most conveniently assembled on an operations map.

■ 106. SPECIAL RADIO SERVICES.—*a. General.*—Such special radio services as the transmission of time signals, press reports, and counterpropaganda may be admirably performed through the use of a special service transmitter station. Operation and control of such a station, if used, are the responsibility of the superior headquarters in the theater, but when several armies or groups of armies are operating in the same theater each army may be required to operate and control such a station for use within its own area. The special service station should not operate in any tactical net and should not be located within a mile of any headquarters or other major establishment. The power required is a function of the extent of the area for which service is desired. Transmissions from such stations are in the clear, and acknowledgments of transmissions are prohibited. Schedules showing the time, frequency, and nature of the service to be rendered by broadcasts from special service stations are included in the signal operation instructions assigning frequencies to the command.

*b. Time signals.*—Special service stations are particularly adaptable to the broadcasting of time signals. When so used the following procedures are observed:

(1) A regular schedule of these broadcasts is observed, and variations because of contemplated tactical operations are not permitted.

(2) Each headquarters or establishment served is informed, by means of the signal operation instructions indicated in *a* above, of the approximate times of the broadcasts and the frequencies and the type of transmission employed thereon.

(3) All receiving stations exercise care to insure that time signals being utilized are in fact those emanating from the special service station. This is not difficult as any transmitter used has a distinctive note which may be identified.

(4) An accurate source of time, preferably associated with a device for mechanically or electrically controlling the transmission, is made available to the transmitting station.

(5) Time signals are broadcast a sufficient number of times, each on a different frequency, to insure that each unit in the area, down to and including battalions, receives the time signals at least once every 24 hours.

*c. Press reports.*—The special service station may also be employed advantageously to broadcast press reports. (See FM 30-25.) When so used the following procedures are observed:

(1) Prior to broadcast, each report is approved by the commander of the unit (usually for him by G-2) under whose control the special service station is operating.

(2) The signal operation instructions indicated in *a* above state the times of the broadcasts and frequencies employed thereon.

(3) Emphasis is placed on the instructions that no traffic in tactical nets will be delayed in order that these press broadcasts be copied.

(4) Stations in tactical nets are not permitted to retransmit information which was received on a press report broadcast.

*d. Counterpropaganda and blocking transmissions.*—(See FM 30-25.) Special service stations may be utilized to transmit counterpropaganda. Voice broadcasts in the language of the enemy and the transmission of false information in the clear or in simple code or cipher may prove advisable but are

not transmitted without specific orders of the superior commander in the theater. The blocking of hostile propaganda broadcasts, which is attempted in every case, or of other radio communication, which may be desirable in special cases, may be found feasible, but in general a special service station will not prove particularly efficient for these purposes. Separate transmitters or other devices for these purposes are installed and operated whenever necessary. Neither counter-propaganda broadcasts nor blocking transmissions will be mentioned in signal operation instructions.

*e. Meteorological data.*—Meteorological data are not broadcast but are transmitted as are other messages.

■ 107. CONTROL OF CIVIL RADIO STATIONS.—*a. General.*—All available information as to existing radio stations in the theater of operations is supplied to the commander of the theater by the War Department. The chief signal officer of the theater checks and supplements this information by thorough ground reconnaissance and through the employment of the radio intelligence company. (See ch. 7.)

*b. Commercial stations.*—(1) *Regulation.*—In conformity with orders and directives of the theater commander, the chief signal officer silences certain or all of the commercial stations in the theater, and so regulates the operation of those not silenced as to prevent interference with military radio communication and to insure that information of our forces does not reach the enemy through this channel.

(2) *Employment for military use.*—Certain of the commercial stations may be utilized to supplement the military stations. When taken over and operated by, or under direct supervision of, military personnel, operation of the station conforms to all regulations and procedures prescribed for stations in the military system. When the theater of operations is considerably removed from the zone of the interior, as with an oversea expeditionary force, and wire communication is not available, a commercial station may prove a valuable asset. Automatic keying, "speech scrambling" devices, and automatic machine encoding, in addition to the normal prescribed encoding, will, in general, improve signal security on such a channel. Installed commercial stations may also be

found suitable for use as special service stations. (See par. 106.)

*c. Private stations.*—(1) *Transmitting.*—In general, all private transmitting stations, such as amateur stations, within the theater of operations are silenced. If, however, it is found desirable to take over the operation of any such station, it is operated in conformity with regulations and procedures prescribed for stations in the military system.

(2) *Receiving.*—Receiving sets in the hands of the civil population will be licensed and registered or confiscated only to the extent directed by, and in conformity with, orders of the theater commander.

## SECTION VII

### WIRE COMMUNICATION

■ 108. *SCOPE.*—*a.* Wire communication as employed within the division and lower units is completely covered in FM 24-5. Since those units usually employ field wire lines, that manual contains all information and instructions regarding lines constructed with field wire and the equipment and records associated with such lines in those units.

*b.* This section covers the employment of wire communication in higher units, wire lines constructed with other than field wire, and the equipment and records associated with such lines in those units.

*c.* Terms used in wire communication and defined in FM 24-5 are given the same meanings in this manual.

■ 109. *WIRE SYSTEM.*—*a.* As in smaller tactical units, the wire system of large units consists of the telephone and telegraph facilities installed by the personnel assigned to the headquarters of those units, including those facilities installed by others which have been taken over by the units for supervision, operation, or both. For example, the army wire system includes the wire communication facilities installed by the army signal service and those supervised or operated by that service.

*b.* The wire system includes all means of signal communication utilizing wire lines. As regards matériel, it consists of wire lines, usually called the outside plant, and the connect-

ing, operating, and testing equipment for use therewith, usually called the inside plant and installed in centrals.

c. With such modifications as are imposed by movement, supply, and the time permitted for installation, the wire systems of units larger than the division and in rear areas conform in their methods, equipment, and operation, to those of the commercial industry in the United States.

■ 110. WIRE PROJECTS.—*a.* The character and extent of the wire system of a corps or larger unit for a given campaign vary from those of other campaigns under the conditions imposed by the nature of the campaign, composition of the forces employed, distances involved, supply conditions, and numerous other factors, of which one is the need for adjustment to an existing wire system in the theater of operations.

*b.* A modern commercial wire system, such as is essential for the handling of the heavy traffic in the rear areas of a large force, requires for its installation an immense expenditure of time, labor, and money. An existing commercial system in the theater of operations, if properly safeguarded and used, may represent a valuable contribution to the success of the force operating in that theater. To capitalize on the advantage that may be thus offered, the existing system is not scrapped and an entirely new one built, but the former is studied and extensions thereto are so planned that they may supplement the existing system.

*c.* After a careful study of the conditions applying to a projected campaign, the War Department or the superior headquarters in the field arrives at a decision concerning the technical and physical characteristics of the wire system for that campaign. Wire projects are prepared showing modifications in the existing system, new construction, bills of material, and equipment, and priorities are given these projects. Division signal troops and systems are not appreciably affected by conditions peculiar to a certain campaign. Their equipment is largely noncommercial, and the scheme of organization in the division is crystallized over long periods of time. On the other hand and at the other extreme, the signal units in rear areas are units whose equipment is subject to major modification for different projected campaigns. Corps signal units and systems represent the marginal or border

line case. In some situations corps signal units may install, operate, and maintain systems using field wire and approaching those of divisions; in other situations their systems may use more permanent types of construction and approach those found in larger units or in rear areas; and in the most usual situation their systems are a combination of both types.

■ 111. LINES.—*a. Standard open wire.*—Standard commercial open wire construction, consisting of bare copper or iron wire carried and spaced on standard cross arms supported on wood poles, offers many advantages for the wire lines of corps, armies, and rear areas. It is protected from troops and vehicular traffic and is easily maintained. Experience has shown that damage to such a line from the blast of a projectile exploding nearby is negligible.

*b. Improved open wire.*—When supply, transportation, and time factors will not permit standard open wire construction, a much lighter construction using improvised poles, cross arms, and hardware to the extent necessary may have to be substituted. However, when planning any wire line the likelihood of later expansion to accommodate more circuits is considered. The desirability of providing a more rapidly constructed line which will meet only immediate needs is weighed against an eventual loss of time, labor, and materials when an entirely new line must be constructed to meet expanding needs for additional circuits along the same route. To the extent possible under the circumstances, any open wire pole line constructed for military use during field operations should be capable of expansion to meet its probable future need for a greater number of circuits without the replacement of either poles or cross arms.

*c. Insulated wire.*—Wire W-110 or W-110-B, both of which are described in FM 24-5, is field twisted pair insulated wire most generally used for field wire lines. The need for field wire in division and subordinate systems makes it essential that whenever a shortage thereof exists standard commercial wire should be used on superior systems in lieu of field wire wherever possible. Commercial twisted pair insulated wires which are used similarly are wire W-38, consisting of two solid No. 17 copper-clad steel tinned conductors, commonly known as outside distributing wire; and wire W-50, consisting

of two solid No. 14 hard copper conductors, commonly known as outside twisted pair. These wires are most suitable for use in rear of divisions, for local and short trunk circuits, and for hastily constructed or repaired circuits in general. Wire W-108, consisting of two solid No. 17 copper-clad steel or bronze conductors, commonly known as parallel drop wire, is also suitable for short local circuits.

*d. Commercial cable.*—Deeply buried cables of the paper insulated, lead covered varieties and submarine cables may be used where the situation permits. Similar cables with steel tape armor protection are also available and are less vulnerable to shell fragments or accidental damage. Mechanical devices for trench digging or for plowing under such cables will, under special conditions, give buried cable lines an application in a future major conflict. An undesirable feature of such cables is that a puncture of the sheath usually results in the eventual loss of all circuits.

*e. Military cable.*—Special military rubber insulated and jacketed cables of 5 and 10 pair may be laid on the ground, supported on poles or trees by such means as are available, and do not require messenger strand to support them. They are especially desirable in the vicinity of larger headquarters, in lines through congested areas, and to permit laying a line of 5 or 10 circuits at one time.

(1) *Five pair.*—Cable WC-534 is of 5 pair. Cable assembly CC-345 consists of this cable equipped with molded rubber terminals permitting rapid connection between assemblies. This assembly may be obtained on a reel of one-half mile or in coils of 100, 200, and 500 feet. Cable stub CC-344 consists of a 10-foot length of cable WC-534 equipped with a similar molded rubber terminal on one end only. Plug jacket M-193 is a large size heavy rubber band about 1 inch wide for sealing the joint of two of these molded rubber terminals.

(2) *Ten pair.*—The 10-pair types are similar to (1) above, the nomenclature being cable WC-535, cable assembly CC-355, cable stub CC-354, and plug jacket M-194, respectively. The longest cable assembly CC-355 obtainable is a reel of 1,000 feet instead of the one-half mile length of the cable assembly CC-345.

■ 112. TELEPHONE CENTRAL EQUIPMENT.—A telephone central includes terminal and other frames, switchboards and power equipment, protective equipment, testing instruments, and other accessories. (See par. 115.) The installation is usually expensive, fairly delicate, and requires suitable housing. It is installed, operated, and maintained by highly specialized and trained personnel. The field forces make use of telephone central equipment which has been designed especially for military use, as well as that of standard commercial design. Military switchboards are local battery nonmultiple switchboards, but adoption of common battery types may be expected for large units. Commercial switchboards may be either local battery or common battery, multiple, or nonmultiple, depending upon the number of telephones to be served, the kind of service desired, and the length of time a headquarters is likely to be in one location.

a. Divisions and lower units use switchboards designed especially for military use. (See par. 142.)

b. (1) Corps and larger headquarters and other large establishments generally require a system of such capacity that standard military equipment will not suffice. (See par. 147.) Pending the adoption of standard military equipment, commercial switchboards are used. American manufacturers of telephone switchboards make several different designs none of which fulfills exactly the requirements of a large military headquarters but with slight modification can be made satisfactory for the purpose.

(2) These headquarters and establishments may also find it expedient at times to use existing commercial telephone facilities instead of installing a special system. Especially is this likely to be the case when a headquarters is located in friendly territory. When existing commercial systems are used, they may be operated and maintained by civilian personnel under an agreement between the military authorities and the commercial company; they may be operated and maintained by civilian personnel under the supervision of military authorities; or they may be taken over and operated exclusively by the military forces. Location and circumstances will govern in each case.

(3) The time required to install a switchboard to serve a corps, army, or GHQ ranges from 6 hours for small non-multiple switchboards to several weeks for large multiple installations. Therefore, when a large system is required it will generally be found necessary to install initially a small switchboard to take care of the more important traffic pending the installation of an adequate central.

(4) Nonmultiple switchboards, either local or common battery, may be removed without being completely dismantled, and may be reinstalled without difficulty, provided reasonable precautions are taken in handling them. Commercial multiple switchboards must be practically dismantled upon removal and will generally require overhauling before reinstallation.

(5) Small systems of from one to three positions are generally of the nonmultiple type. Local battery systems of more than three positions may be of the multiple type, though they are more often nonmultiple and served by interposition trunks. Common battery systems of more than three positions are generally of the multiple type.

■ 113. LOCAL BATTERY SYSTEMS.—*a. Advantages.*—There are many small telephone systems where the number of lines served and the expected life of the system make the use of a local battery system advantageous. Its principal advantages over the common battery system (par. 114) are—

(1) The outside plant can be constructed more cheaply and quickly.

(2) The inside plant is less complex and costly.

*b. Disadvantages.*—The disadvantages of the system are—

(1) Dry cells are an expensive source of power.

(2) The replacement of dry cells in widely separated local battery telephones is a time consuming process.

(3) The telephone is bulky.

(4) The turning of the hand generator to signal the operator requires conscious effort on the part of the user.

(5) Failure on the part of the user to ring off when conversation is completed increases the work of the operator and reduces the availability of circuits.

■ 114. COMMON BATTERY SYSTEMS.—*a. Advantages.*—The use of a common battery system overcomes all of the disadvantages listed in paragraph 113*b* in that—

(1) A single source of power for use by all stations is centrally located.

(2) This source of power is a storage battery which is very efficient.

(3) The telephone is less bulky since the hand generator is unnecessary.

(4) Automatic signaling and supervision reduce the work of the switchboard operator, allowing one operator to handle about twice as many circuits as he could handle on a local battery system.

(5) Only the hanging up of the receiver by the user is necessary to indicate completion of the conversation.

*b. Disadvantages.*—As compared with the local battery system, the disadvantages of this system are—

(1) The outside plant must be of a higher quality.

(2) The inside plant requires a longer period for installation and is far more complex, delicate, and expensive.

■ 115. TYPE AND SIZE OF TELEPHONE CENTRALS.—*a. Requirements.*—The type and size of central office equipment used in military telephone centrals, except in the division and its component units, vary with the situation to such an extent that no definite requirements can be stated. Therefore the statements as to type and size of equipment required at the various headquarters given in *b*, *c*, *d*, and *e* below are intended to serve only as a guide. While all of the items listed are generally needed, circumstances may require additional items. The actual equipment needed for a particular installation under a given situation can be determined only by an analysis of the service requirements. In making such an analysis the following questions present themselves:

(1) Does the situation warrant local or common battery?

(2) How many local telephones are needed?

(3) How many long-distance circuits are required?

(4) How many local telephones can an operator handle?

(5) How many local positions are needed?

- (6) How many toll circuits can an operator handle?
- (7) How many toll positions are needed?
- (8) How many local cord circuits are needed per position?
- (9) How many toll cord circuits are required per position?
- (10) How many repeater cord circuits, if any, should be provided for toll positions?
- (11) How many local line circuits should there be per position?
- (12) How many toll line circuits are needed per position?
- (13) How many circuits will be phantomed?
- (14) How many circuits will be composited?
- (15) How many circuits will be simplexed?
- (16) How many and what type repeaters, if any, are required?
- (17) What provision should be made for future growth?

*b. Division.*—The division uses the switchboard BD-14. Its entire central office will usually consist of 1 switchboard BD-14, 1 terminal frame of sufficient size to accommodate 40 lines, and a test set EE-65.

*c. Corps.*—The wire telephone central of a corps generally consists of the following major items:

(1) A transportable manually operated local or common battery switchboard of 2 to 3 positions, each position having a capacity of 80 to 100 lines and equipped with 12 to 15 cord circuits.

(2) One main distributing frame which may be arranged in sections to correspond to the sections of the switchboard.

(3) One wire chief's test set.

(4) Two ringing machines, one for battery operation and the other for operation from 110 volts a. c. when that source of power is available.

(5) If the system is common battery—

(a) One or two banks of storage batteries of 24 volts each.

(b) Battery charging equipment for operation from 110 volts a. c., if available, or from a gasoline engine driven generator.

(c) Gasoline engine driven generator for use in charging batteries when local power is not available.

*d. Army.*—An army headquarters generally requires a switchboard of from 6 to 10 positions. The type of installa-

tion most suitable depends upon the class of service desired and the degree of permanence of the installation. It varies from the installation described for the corps, through a semi-permanent manually operated common battery switchboard, to a completely automatic exchange. When the army headquarters is to be located in one place for a short time, the central is generally of the type described for the corps. When the stay in one place is to be for an extended time, the central is generally a common battery installation. In general, automatic exchanges are feasible only when plants of this type are already installed and can completely serve the army establishments. Where a common battery system is required, the items of equipment needed are generally as follows:

(1) One common battery multiple switchboard with 2 toll positions and from 4 to 8 local positions. Each toll position should have a capacity of from 10 to 20 lines and from 8 to 12 cord circuits. The capacity of local positions should be from 80 to 120 lines and 12 to 17 cord circuits.

(2) One combination main and intermediate distributing frame with a capacity of from 600 to 1,200 lines.

(3) One relay rack and fuse panel.

(4) One combined local and toll test board.

(5) Two 24-volt storage batteries, capacity dependent upon current required.

(6) One charging set (mercury-arc or motor generator).

(7) One emergency charging set.

(8) One power panel.

(9) One power protection panel.

(10) Two ringing machines.

(11) One chief operator's desk.

(12) Miscellaneous toll equipment dependent upon service requirements.

*e. Other headquarters and establishments.*—The variety and class of service required by GHQ, depots, and other establishments are such that equipment needs cannot be stated until the service requirements are known. However, the major items are generally similar to those for the army.

■ 116. INSTALLATION OF TELEPHONE CENTRALS.—*a. General.*—

(1) The need for an installation is foreseen as far in advance as practicable. The person charged with the installation is

provided with all necessary information and a plan of installation. He checks his material and ascertains that all items required have been provided. If a shortage exists, he takes immediate steps to obtain the items required.

(2) All central office apparatus is installed by an installation detail. The line construction detail is responsible for making the outside circuits available to the installation detail at the central office main frame.

(3) Circumstances are often such as to require that the work of installation should be carried on continuously from the time it is begun until it is finished. This may necessitate two or three reliefs of men. Where more than one relief is required, close coordination is essential. One individual is placed in general charge of the work and is held responsible for the entire installation.

*b. Protective equipment.*—Lightning and electrical power circuits constitute hazards to telephone plants. Wherever such hazards exist, central office apparatus must be protected. There are three means of protecting central office apparatus against outside hazards: Lightning arresters for protection against lightning; fuses for protection against electrical systems of more than 220 volts; and heat coils for protection against circuits of 220 volts or less. All central office battery and ringing leads are equipped with central office fuses to protect against excessive currents.

*c. Grounds.*—A central office ground is installed as described in paragraph 152. Separate heavy leads are run from the actual ground plate to the central office providing a different lead on which to ground the battery, the protective equipment and, in large systems, the ringing machines. The lead employed to connect the battery to the ground plate must be particularly heavy or cross-talk between circuits may result.

*d. Arrangement.*—The central office arrangement should be convenient and should be such as to allow for anticipated future growth. The factors governing in various situations are such that no particular plan can be prescribed.

#### ■ 117. MAINTENANCE OF TELEPHONE SYSTEM.—*a. References.*—

(1) The maintenance of field wire systems employing military equipment is adequately covered in FM 24-5.

(2) For more detailed information than is contained herein as to the maintenance of other than field wire systems employing construction and equipment approaching that used commercially, see chapter 9.

*b. General.*—(1) The proper maintenance of a telephone system is an important factor in rendering satisfactory service. Good service may be given over a poorly constructed system so long as it is well maintained and operated. Poor maintenance precludes the possibility of satisfactory service under any circumstances.

(2) The central is the most difficult part of a system to maintain. The apparatus is comparatively delicate and the circuits in many cases are complicated. Trouble on one circuit will often disrupt all circuits terminating in the same panel and in some cases may place all circuits of the exchange in trouble.

(3) A wire chief has two sources of information relative to the condition of his plant. One is from reports made by users and the other is by routine tests and inspections. He makes full use of both. Reported troubles are generally the results of interrupted service and are given immediate attention. Since interrupted service is highly undesirable, a wire chief lessens the number of cases reported by making systematic routine inspections and tests. Maintenance conditions of a system are reflected in the number of cases of trouble reported; the fewer the number, the better is the maintenance.

*c. Routine inspections.*—All equipment in the central office is inspected daily for broken, missing, or damaged parts. Special attention is given to the operating positions for worn cords and plugs and sticky switchboard keys. Ringing machines are carefully observed for burnt contacts, sparking brushes, and worn commutators. The condition of the storage batteries is noted and recorded.

*d. Routine tests.*—The following circuits are tested as indicated and defective conditions found are corrected.

(1) Test all cord circuits daily for ringing, talking, and supervision. Make a current flow test monthly and adjust relays to operate and release on the proper values of currents.

(2) Test all trunk circuits daily for insulation, talking, and signaling. Make a current flow test and adjust relays monthly.

(3) Test all line circuits monthly for insulation, talking, and signaling. Make a current flow test and adjust relays monthly.

(4) Test operators' telephone circuits daily for talking and listening.

(5) Test pilot and night alarm circuits daily for operation.

(6) Test ringing and charging machines daily.

(7) Test all miscellaneous circuits weekly.

(8) When telephone repeaters or other special apparatus is installed, make tests as prescribed in the operating instructions.

(9) In addition to the periodic tests prescribed above, always make a thorough test of a circuit each time a case of trouble is cleared.

■ 118. WIRE SYSTEM RECORDS AND REPORTS.—*a. Reference.*—For the records and reports pertaining to field wire systems, see FM 24-5.

*b. General.*—Of major importance in the operation of the wire system is the maintenance of complete, accurate records thereof. In hostile territory when possession is taken of wire facilities, every effort is made to secure all records of the wire system of which those facilities are a part. Without such records even partial use of the system is extremely difficult. For this reason, when a central must be abandoned to the enemy, all records applicable to the system are removed or destroyed.

*c. Records.*—(1) The following list shows the records normally required and by whom they are kept:

Name of record	Kept by	Form
Maps of system.....	Signal officer.....	
Equipment drawings.....	Signal officer and wire chief.	
Cable record.....	Wire chief.....	W. D., S. C. No. 1160.
Line record.....	do.....	W. D., S. C. No. 1156.
Storage battery record.....	do.....	W. D., S. C. No. 1173.
Operators' schedule.....	Chief operator.....	
Information card file.....	do.....	
Special records.....	As required by the signal officer.	

(2) Maps or sketches show the layout of the system.

(3) Two sets of equipment drawings, circuit drawings, and floor plans should be kept on file. The signal officer retains one set and the other is kept by the wire chief for reference.

(4) For each cable installed a cable record is prepared showing the number of the cable, whether submarine, aerial, or underground, number of pairs, gage of conductors, and type of cable; date installed, terminal numbers, and locations; the number of the circuit working out of each terminal. This record is kept by the wire chief as a ready reference for locating trouble and for switching circuits from one pair to another.

(5) A separate line record card for each local and trunk circuit installed is filled in by the wire chief and retained for reference. The card shows the telephone number, the date installed, official position and address of user, loop resistance of the circuit, kind of telephone, cable number, pair number, and terminal number. In addition the card contains a trouble record showing the date and hour of each case of trouble reported, by whom reported, nature of trouble reported, trouble indicated by test, actual trouble found, date and hour cleared, and by whom cleared. The data contained on this card are invaluable as an aid to maintenance and also form a basis for the chief operator's information card file.

(6) When a storage battery is installed, a record of its initial charge is prepared by the installer and turned over to the wire chief. This record shows the number of the battery, the number of cells, type of cells, number of plates per cell, the capacity of plates, date and hour charge started, normal charging rate in amperes, and the date and hour of completing charge. In addition, it contains a record of hourly readings taken throughout the duration of the charge, showing the time of readings, rate of charge, voltage reading, hydrometer reading, temperature reading, and corrected specific gravity reading. This record also contains a column of remarks covering any unusual occurrences during the installation or the initial charge.

(7) The wire chief prepares a similar record for his monthly storage battery report, except that his readings are taken as indicated on the form for that report.

(8) The operators' schedule is usually prepared by the chief operator and approved by the signal officer before being placed in effect. It shows the number of operators, their tours of duty, periods of relief, and contains a column of explanatory remarks when necessary.

(9) The information card file kept by the chief operator is used by the chief operator or the information operator to furnish subscribers with information respecting calls. It also serves as a basis for the telephone directory. The data for preparing the information card file are taken from the line record cards.

(10) In addition to the foregoing list, special records may sometimes be required.

*d. Reports.*—(1) The signal officer always submits to the next higher authority a report of the installation of his wire system and a report of its discontinuance or removal. In addition, special reports may be called for from time to time.

(2) The report of installation contains all information necessary to acquaint the higher headquarters with the situation and to form a basis for any reports such headquarters may be required to render. There is no prescribed form for the report. The report of discontinuance or removal is accompanied by all records pertaining to the system.

(3) The wire chief submits to the signal officer a monthly report containing the following information:

(a) Number and classification of troubles experienced during the period.

(b) Number of installations and removals.

(c) Storage battery record.

(d) Recommendations for improvement of service.

■ 119. **TELEPHONES.**—*a. Choice of types.*—Telephones EE-8, EE-8-A, and EE-4 are designed for operation and may be used on either local or common battery systems. The need for these types of telephones on division and subordinate systems and the fact that their procurement is more difficult make it essential that, whenever possible, standard commercial telephones be used on superior unit systems. The type of commercial telephone required depends upon the character of the system installed.

*b. By whom required.*—The commander of the unit, upon recommendation from the signal officer, designates those offices and establishments at which telephones will be installed. Within the limits of the available equipment, and the time available for installation, telephones should be provided wherever their need is indicated. In cases where the demand for telephones exceeds the capabilities of the equipment and personnel available, the signal officer recommends a priority of installation to the commander.

*c. Location.*—(1) The telephone is located in accordance with the wishes of the user, but he is informed that observance of the following cautions will probably result in greater utility of the telephone to him:

(a) Do not locate it on a damp wall.

(b) Keep it away from windows.

(c) Do not expose it to injury by opening doors.

(d) Avoid noisy locations.

(e) Do not install it near a radiator or hot-air register.

(f) Do not locate it so that inside wiring must be run along the floor or in any place where it will be constantly exposed to accidental injury.

(2) Locate wall sets with the transmitter 5 feet from the floor.

*d. Maintenance.*—A periodic inspection is made of all telephones in service, and the quality of service rendered by them is checked at that time.

■ 120. TELEGRAPH COMMUNICATION IN GENERAL.—The importance of telegraphy to military communication can hardly be overestimated. It is more rapid, reliable, and accurate than any other means of signal communication now in use. Full use of the telegraph materially relieves congestion on the telephone system. (See sec. VII, ch. 9.)

■ 121. TELEGRAPH LINE CIRCUITS.—Each telephone circuit may provide one or two ground return telegraph circuits depending on whether this telephone circuit is simplex or composited.

*a. Simplex circuit.*—The simplex circuit is completely covered in FM 24-5.

*b. Composite circuits.*—The composite circuit provides two telegraph circuits and one telephone circuit over one metallic

circuit. Its wiring is rather complicated, and considerable apparatus in addition to that needed for an ordinary telephone circuit is required. (See par. 161.)

■ 122. TELEGRAPH CHANNELS.—*a. General.*—One telegraph line circuit may be used to establish a single telegraph channel through the employment of manual single-line telegraph terminal equipment. This is known as single-line telegraphy. Two channels may be established over the one line circuit through the use of manually operated duplex terminal equipment. This is known as duplex telegraphy and permits simultaneous transmission and reception at each terminal station. Telegraph printers, which operate on either the single-line or the duplex system, will handle several times the volume of traffic that can be moved on the manually operated systems.

*b. Single-line telegraphy manually operated.*—In general this system is satisfactory for use where the traffic load on the telegraph circuit does not exceed 28 to 36 messages of average military length per hour (14 to 18 each way). A minimum of equipment is required and maintenance of the terminal equipment presents a minor problem. Efficient operation of this system requires a highly trained operator.

*c. Duplex telegraphy manually operated.*—Several methods of duplex telegraphy exist: The single current differential, the double current differential, the single current bridge, the double current bridge, and the Morris short line duplexes. Duplex telegraphy should be employed only when the volume of traffic exceeds that which can be moved by single-line telegraphy, and when circuits for establishing additional single-line telegraph channels are not available. Considerably more equipment is required for the installation of any duplex circuit than for the single-line circuit, and the care and adjustment of the former are much more critical. A properly adjusted duplex circuit will, in general, handle a traffic load of 50 to 70 messages of average military length per hour (25 to 35 each way). As in single-line telegraphy, a highly trained operator is required.

*d. Telegraph printers.*—(1) *General.*—A telegraph printer is a machine which, when connected by a wire circuit with

one or more similar machines, transmits messages to them when its typewriter keyboard or tape transmitter is operated, the message transmitted being automatically typewritten on both the transmitting and the receiving machines. Although decisions as to military standardization and basis of issue of telegraph printers have not been made, use thereof may be expected at division and higher headquarters. The printer is of greatest value when the volume of traffic is heavy, and especially when long routine administrative messages containing many numerals are to be transmitted. For direct communication between offices, it is sometimes more desirable than the telephone in that it has the added advantage of recording for the sender and receiver the messages transmitted. In such cases, typists for operating the printers are furnished by the offices in which the printers are installed. Examples of such direct communication which under certain conditions may prove extremely valuable are—

(a) Office of G-3 of the army or GHQ to the office of G-3 of each of the next subordinate units.

(b) Office of G-4 of the army or GHQ to most important army or GHQ supply establishments.

(c) Operations office of the GHQ Air Force to its next subordinate units.

(2) *Traffic networks.*—Direct intercommunication between two printers is warranted when the volume of traffic between the offices or the headquarters at which the printers are installed is sufficiently great to keep the line relatively busy, and the information transmitted need not be immediately retransmitted to a third office or headquarters. A telegraph loop of as many as five stations in a net is warranted when the total traffic load on the loop is not so great as to delay transmission of messages from any one station in the net, and where messages transmitted by any one station may be addressed to several of the stations in the net. Technical difficulties will prevent satisfactory operation of this net if the total length of the field wire loop is over 12 miles or if any section of the line is in poor condition. At GHQ and army headquarters it probably will be found desirable to establish a telegraph printer exchange to furnish telegraph printer service for several offices of the headquarters and

at various other headquarters establishments in the area. To establish this service a telegraph printer switchboard with associated repeaters is essential. On such a system any station may be interconnected, on signal to the exchange, with any other station served by the exchange, or over trunk lines through a second switchboard, with a local station on the second switchboard. Conference circuits of as many as five stations may be set up at the exchange, allowing operation of a loop as indicated above. Finally, the circuits may be switched at the exchange so as to allow any one station on the system to transmit to all of the other stations.

(3) *Powers and limitations.*—The telegraph printer will move efficiently a traffic load of 80 to 100 messages of average military length per hour. Any skilled typist may be quickly trained as an operator. Maintenance of the printers requires a highly skilled specialist and must not be attempted by the printer operator.

■ 123. **MANUAL TELEGRAPH PROCEDURE.**—On all circuits employing the International Morse Code, telegraph operating procedure conforms to that prescribed in FM 24-5.

■ 124. **TELEGRAPH PRINTER PROCEDURE.**—The following operating procedure is authorized for use on telegraph printer channels. This procedure is basically the same as manual telegraph procedure (par. 123) but with the differences indicated below:

*a. Limitation on deviations.*—Deviations from the following procedure are authorized, but all messages must be receipted for, and except in the case of a flash message every message must contain the message serial number and the call sign of the transmitting station. See *e* below for an additional limitation.

*b. Basis.*—This procedure is based on the assumption that printers upon which traffic is to be handled are directly connected and are in readiness for operation. On circuits employing printers which are equipped with the start-stop remote control feature, or on which auxiliary signaling equipment is installed, calling procedure will be modified to take full advantage of all opportunity for saving time in the movement of traffic.

*c. Call sign.*—All telegraph printers installed at one station use the call sign assigned to that station.

*d. Bell signals.*—The following bell signals with the meanings listed are used:

Signal:	<i>Meaning</i>
1 bell.....	End of transmission.
2 bells.....	I am starting.
3 bells.....	Broadcasting to all stations or conference message.
4 bells.....	Stop transmitting until signaled to go ahead.
9 bells.....	You are wanted at the printer; attention.

*e. Abbreviations.*—The following abbreviations with the meanings listed may be used in addition to the procedure signals prescribed in JANP. Additional abbreviations may be found advisable, but none may be authorized which conflict with or supplant any procedure signal listed in JANP.

<i>Abbreviation</i>	<i>Meaning</i>	<i>Abbreviation</i>	<i>Meaning</i>
AGN.....	Again.	NIL.....	Nothing to transmit.
ANR.....	Another.	OK.....	All right.
BDCST.....	Broadcast.	PLS.....	Please.
GB.....	Goodbye.	RDY.....	Ready.
GM.....	Good morning.	TNX.....	Thanks.
GN.....	Good night.	TR.....	There.
HR.....	Here.	U.....	You.
LO.....	Hello.	UR.....	Your.

*f. Forms and precedence of messages.*—Messages are either normal form or flash messages.

(1) *Normal form.*—The classifications of normal form messages and the precedence in handling them are completely covered in FM 24-5.

(2) *Flash.*—If, in order to meet a special situation where time is of utmost importance, a commander prescribes in detail the form of certain messages and definitely limits the content and arrangement thereof, these messages may be called flash messages. The commander prescribing them will indicate the precedence which will be given them over those in (1) above, except that they will not be given precedence over urgent messages from higher authority. He will also prescribe so much of this procedure for transmitting them as he considers necessary (see *a* above), and the procedure prescribed by him will provide that all such messages when

transmitted will be preceded by the word **FLASH**, and that receipt for all such messages must be given.

*g. Call and answer.*—(1) The following examples illustrate the call and answer. Stations **PL**, **QN**, **JM**, and **WG** are the station call signs of four stations connected on a loop. (Par. 122 *d* (2).)

**QN** calls **PL**: (2 bells) **PL V QN** (1 bell).

**PL** answers: **QN V PL K** (1 bell).

**QN** calls **PL**, **JM**, and **WG** for conference or broadcast message:

(3 bells) **PL JM WG V QN** (1 bell).

**PL**, **JM**, and **WG** answer as above in the order called.

(2) After stations on a single circuit have been working with each other and operators are satisfied that calls are unnecessary, the call and answer may be omitted.

*h. Transmitting messages.*—Operators see that adequate paper is available for the reception of each message. On page printers at least 5 inches of paper for each message should be allowed. The parts of each normal form message are transmitted in the following order:

(1) *Heading.*—The heading includes, in sequence, the message serial number, call sign of the transmitting station (see *a* above), message classification (**O**, **P**, or **D**), the office or headquarters of origin, time filed, the month (abbreviated), the day of the month, and the addressee. For additional serial numbers and call signs to be transmitted in a broadcast message, see (5) below.

(2) *Text.*—The text includes the body of the message, the signature, and the writer's time as written (if any).

(3) *Ending.*—The ending includes the word **SENT** followed by the time when the last word of the text was sent, on the second line below the signature, and the signal 1 bell if there are no more messages to transmit.

(4) *Example of a message to one station.*—The following is an example of the transmission by station **QN** of an urgent message to only one station. The message serial number is 25, **QN** having previously transmitted 24 messages to that station, and upon completing the transmission of number 25 will have nothing more to transmit.

25 QN 0

HQ FIRST ARMY 1010 A DEC 16

CG I CORPS

G TWO REPORT NOT RECEIVED EXPEDITE

CG FIRST ARMY 1008A

SENT 1014A (1 bell)

(5) *Example of a message broadcast to several stations on the same loop circuit.*—The following is an example of the transmission by station QN of a routine broadcast message to stations PL, TD, and JM. QN has previously transmitted 25 messages to PL, 19 messages to TD, and 27 messages to JM.

PL 26 TD 20 JM 28 QN

HQ FIRST ARMY 1100A DEC 16

CG I CORPS

CG II CORPS

CG III CORPS

WILL ISSUE MARCH ORDERS AT 300P

CG FIRST ARMY

SENT 1105A (1 bell)

*i. Receipt.*—The transmission of a message is not regarded as complete until a receipt has been given for it by the receiving operator. (See *a* above.)

(1) The following is an example of a receipt for the message given in *h* (4) above if PL is the call sign of the I Corps and this station has nothing to transmit to the First Army.

R NR 25 1015A PL (1 bell)

(2) A receiving operator having received a string of messages on a continuous transmission may receipt for the entire string on a single transmission. For example, PL having transmitted to JM messages 7 to 10, inclusive, on a continuous transmission, JM receipts as follows:

R NRS 7-10 1030A JM (1 bell)

*j. Corrections.*—To obtain a correction or repeat of any transmission, wait until the end of the message or until a prearranged break in a very long message, as at the end of a sheet, and then request a correction. If, in the example given in *h* (4) above, the word REPORT was the last word received

correctly and the word **EXPEDITE** was the first word received correctly after the error or omission, the request for a correction is:

**IN NR 25 IMI REPORT TO EXPEDITE (1 bell)**

*k. Group count.*—In this procedure, no group count has been included in the heading of a message. Operators therefore carefully examine the copy of the message as it is received in order to correct obvious omissions of words or phrases should these omissions occur. As a further check on the accuracy of transmission it may be necessary to prescribe that, upon completion of transmission, the copy printed on the transmitting printer be compared with the original message.

■ 125. **CARRIER SYSTEMS.**—*a. General.*—The carrier principle may be used in both telephone and telegraph communication, and in either case the object is the simultaneous, independent transmission of several messages over a single circuit, usually without affecting the ordinary message-carrying capacity of the circuit. The term “carrier” derives from the fact that alternating currents of certain selected frequencies are employed “to carry” the messages. More specifically, the variations of current making up the normal telephone or telegraph message are impressed on the carrier current, and are transmitted over the line by currents whose frequencies are of the order of the carrier frequencies rather than of the impressed message current.

*b. Commercial systems.*—Although a military carrier system has not been standardized, several commercial systems are available which may be adapted to use on wire systems of larger units. Of these, type H-1 seems most suitable for use on military wire systems. A summary of the characteristics of this system is made below:

(1) It is applicable to open wire lines with a minimum of modification to the existing facilities.

(2) One carrier telephone channel is superposed on each physical circuit.

(3) One simplex telegraph channel is superposed on each physical circuit in addition to the telephone carrier channel.

(4) Fairly long distances can be spanned without repeaters.

(5) Minimum cross talk is encountered resulting in more efficient operation of several systems on a pole line without extensive changes to the line transposition system.

(6) Short sections of intermediate cable in the line are less serious and remedial measures such as loading are less costly.

(7) It operates on a. c. or d. c., simplifying the installation of terminals and repeaters.

(8) Bridging intermediate telephone stations on the physical pair by use of filters is feasible.

(9) It may be used on a phantom circuit which is used as a trunk circuit even when the side circuits are equipped with bridged telephones along the line.

(10) The carrier apparatus is connected to the line at terminals and repeater points through line filters, which prevent interference between the carrier and voice currents.

(11) It requires little space for installation at the terminals.

## CHAPTER 9

### TECHNICAL, CONSTRUCTION, AND SUPPLY DATA

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#### SECTION I

#### SUPPLY

■ 126. MAINTENANCE FACTOR.—*a. General.*—A maintenance factor has been fixed for principal items of signal supplies used in the theater of operations. This factor is used principally for estimating the requirements for these items for definite periods of time and for making provision for adequate stocks to meet these requirements. It is never used as a basis for requisitions by units using the supplies. It is expressed as a percentage of the initial requirements necessary for maintenance purposes for a month. (See par. 22*b* (1) (*d*).)

*b. Example.*—As an example, it is assumed that Tables of Basic Allowances authorize the issue of 488 miles of wire W-110-B to a large unit, and that the maintenance factor for this wire in the theater of operations is 50 percent. In this example, therefore, it is estimated that this unit will probably require 244 miles of this wire for monthly maintenance purposes, and stocks thereof are provided for in the depot which is to supply this unit in such quantities as are necessary to supply the needs for the period in which this unit is in the theater of operations. If the stock of the depot is to be replenished once each month, 244 miles is the initial maximum stock to be kept on hand for this unit. This maximum is later fixed at a more exact amount determined from actual requirements.

■ 127. REQUIREMENTS OF WIRE W-110 IN COMBAT.—In combat, units requisition only such amounts of wire and other supplies as are needed to bring the quantities on hand up to their authorized allowances. In order, however, for personnel edit-

ing requisitions to act intelligently upon such requisitions, for depots to make provision in advance for the needs of these units in a contemplated tactical operation, and for the signal officer to arrange adequate transportation for the shipment of the supplies needed, an estimate of the quantities of supplies which will probably be needed in that operation is essential. The following tabulation of such requirements of wire W-110 per day of combat, expressed in miles of wire, is based on experience in past operations and best available estimates, and is given as a guide for the purposes mentioned. It is not to be followed blindly, nor to be used after actual experience in operations indicates more correct requirements. In applying this information to any unit or operation, it is essential that the operations of that unit as given in field orders be analyzed and anticipated.

REPLACEMENT REQUIREMENTS OF FIELD WIRE W-110 PER DAY OF COMBAT EXPRESSED IN MILES OF WIRE

Type of combat	"Square" division					"Triangular" division						
	Infantry brigade	Field artillery brigade	Signal company	Others	Total	Infantry regiment	Three infantry regiments	Field artillery regiment (light)	Field artillery regiment (medium)	Two field artillery regiments	Signal company	Total
Attack in a meeting engagement.....	20	160	25	2	227	8	24	54	22	76	30	130
Defense in a meeting engagement.....	10	160	20	2	202	5	15	54	22	76	24	115
Attack of a position:												
First day.....	80	175	40	4	379	16	48	60	24	84	35	167
Succeeding days.....	60	90	30	3	243	10	30	30	12	42	30	102
Defense of a position:												
First day.....	20	110	25	4	179	6	18	36	16	52	24	94
Succeeding days.....	10	90	20	1	131	4	12	30	12	42	20	74
Attack of a zone:												
First day.....	40	90	40	2	212	8	24	30	12	42	35	101
Succeeding days.....	60	90	30	1	241	10	30	30	12	42	30	102
Defense of a zone:												
First day.....	20	165	25	4	234	8	24	55	22	77	30	131
Succeeding days.....	10	90	20	1	131	4	12	30	12	42	20	74
Delaying action.....	60	210	60	4	394	10	30	72	28	100	40	170
Retirement:												
Night.....	20	165	25	2	232	8	24	55	12	77	30	131
Daylight withdrawal.....	80	210	60	4	434	16	48	72	28	100	40	188

## SECTION II

## MESSAGE CENTER

■ 128. TIME INVOLVED IN MESSAGE TRANSMISSION.—*a. Message center.*—(1) *Recording.*—Maximum time permitted for recording operations should not exceed 2 minutes. This is total message center time unless cryptographing is demanded.

(2) *Cryptographing and decryptographing.*—The following rates are based on one man working alone:

Cipher device or code:	Code groups per minute
Cipher device M-94.....	1
Division field code.....	3
Air-ground liaison code.....	3
Fire-control code.....	3

*b. Transmission.*—(1) *Other than messenger.*—The following rates are based on messages of average military length:

Means:	Messages per hour
Telegraph (TG-5, TG-5-A, or other single-line manual) .....	28- 36
Telegraph (duplex) .....	50- 70
Telegraph printer (single-line) .....	80-100
Radiotelegraph.....	15- 25
Radiotelephone .....	10- 15
Lamp .....	10
Semaphore flags .....	15
Wig-wag flag .....	10
Panel .....	<sup>1</sup> 30

<sup>1</sup> Code groups per hour.

(2) *Messenger.*

Kind:	Miles per hour
Dismounted (runner) .....	3- 5
Mounted .....	6- 8
Bicycle .....	6-10
Motor and motorcycle.....	25-40

## SECTION III

## RADIO

■ 129. PURPOSE.—*a.* The purpose of this section is to present technical data on radio sets in ready reference form, the form itself being an indication of a suitable method of assembling data required for the solution of any radio communication problem.

*b.* The data, particularly with reference to types of sets, will not be used in the solution of radio communication problems without checking each item with the Signal Corps General Catalog and Tables of Basic Allowances. *Under no circumstances will these data be used as a basis for requisitions.*

■ 130. RADIO SETS AND CHARACTERISTICS.—The technical data in this paragraph and in figures 1 to 3 cover only those radio sets used within the infantry and cavalry divisions. Data may be assembled on similar forms for radio sets found in other units. Sources of information for the assembling of data of this character are listed in paragraph 131.

Set SCR-	Basic allowance		Type signals		Range, miles	Frequency		Weight, pounds	Description and remarks
	No.	Organization	Transmitting	Receiving		Transmitting	Receiving		
131	1 3	Per Inf BHQ; Inf Bn. See Regtl Hq Co. Per Inf Regtl Hq Co.	CW	CW	5	3,960-4,360	3,960-4,360	76	Loop set carried by 2 men. Comd Net Inf Brig and Regt.
161	1 2 3 4	Per FA BHQ; L Arty Bn Hq; Hv Arty Regtl Hq; M Arty Regtl Hq. Per Hv Arty Bn Hq. Per M Arty Bn Hq.	CW	CW	5	4,370-5,100	4,370-5,100	76	Loop set carried by 2 men. Comd set for FA within Inf Div.
163-A	-----	Same as SCR-203 when that set is not furnished.	CW	CW	40	2,300-2,700	2,300-2,700	154	Pack set for transportation on one anl—replaced by SCR-203.
171	1	Per Sig Co; Inf BHQ; Arty BHQ; M and Hv Arty Regtl Hq; Obsn Bn Hq; Obsn Btry.	CW	CW	15	2,640-3,040	2,640-3,040	180	Carried in vehicle—Comd set Inf Div.
177 or 177-A	1 2 3	Per Opn Co, Army; (CA) (TD) BHQ; Regtl Bn Hq; (Ry) BHQ; Regtl Hq; Bn Hq; Firing Btry; (Ry-AA) Regtl Hq; Bn Hq; (HD) long range Btry; Gn Gp Ft. Per Opn Co (Corps) Div Sig Co; R I Co. AA BHQ; AA Regtl Hq.	CW Tone Voice	CW Tone Voice	100 70 30	400-800 and 1,500-4,500	400-1,000 and 1,500-4,500	900	Carried in vehicle (or plane); Comd set for higher Hq; air-ground set.

178 or 179	1	Per FA BHQ; Bn Hq Btry; per Horse Arty Regtl Hq.	CW Tone Voice	CW Tone Voice	25 20 10	2, 400-3, 700	2, 400-3, 700	203	Intended for air-ground set for FA. When fitted for pack animal transportation is known as SCR-179.
185	1	Per Obsn Ap (C and D).....	CW Tone Voice	( <sup>1</sup> ) Tone Voice	750 500 200	400-4, 700	400-4, 700	380	Obsn Ap set.
193-A 193-B 193-C	1 2 3 7	Per scout car in Regtl Hq Tr (M); scout car and Armd C' Tr; Maint Plat (M); MG Tr (M). Per Sig Tr. Per Cav BHQ (M), Regtl Hq (M). Per Mecz FA Bn Hq	CW Tone Voice	CW Tone Voice	60 40 20	1, 500-4, 500	1, 500-18, 000	230	Vehicular set for use in Tk, Armd C, etc.
194	10	Per L Arty Bn Hq.....	Voice	Voice	5	27, 700-52, 200	27, 700-52, 200	90, *26	Carried by one man, Pk Ani or vehicle. Weight includes spare parts chest. For use within FA Bn.
195	2	Per Inf Regtl Hq; Inf Bn Hq.	Voice	Voice	5	52, 800-65, 800	52, 800-65, 800	91, *26	Carried by one man, Pk Ani or vehicle. Weight includes spare parts chest.
203	1 2 3	Per Sig Tr; L Arty Bn (Horse) when with Cav. Per Cav BHQ (H); Horse Arty Regtl Hq when with Cav. Per Cav Regtl Hq (H).	CW Tone Voice	CW Tone Voice	30 20 5	2, 200-3, 060	2, 100-3, 100	162	Pack set for transportation on one ani. Replaces SCR-163-A.

<sup>1</sup> May receive CW when oscillator equipment RC-12 is used with the set.

\* Weight carried by one man for operation.

‡ Peace strength Cav Regt authorized 3 only.

Set SCR-	Basic allowance		Type signals		Range, miles	Frequency		Weight, pounds	Description and remarks
	No.	Organization	Trans- mitting	Receiv- ing		Transmitting	Receiving		
209	-----	Same as SCR-245 when that set is not furnished.	CW Tone Voice	CW Tone Voice	30 20 5	2, 200-2, 600	1, 500-4, 500	164	Vehicular set--replaced by SCR-245.
210-A	1	Per tank not equipped with SCR-245 or 193; Mecz Arty firing Btry.	-----	CW Tone Voice			1, 500-18, 000	56	Receiver only.
245	1	Per Mecz Arty Bn Hq.							
	1	Per Stf Tk; Comd Tk; Hq Tk Regt; Hq Tk Bn, Maint Co, Tk Regt; (Cav) scout car; Regtl Hq (M); Mortar PL (M); C Car Sq Hq (M); Regtl Hq (H); Regtl Tn (H) BHQ (H); Per Sig Bn; Serv Tr (M); MG TR (M).	CW Tone Voice	CW Tone Voice	45 35 20	1, 500-4, 500	1, 500-18, 000	140	
	2	Per Sig Co; Sig Tr; C Car Tr (M).							
	3	Per Cav BHQ (M).							
	4	Per Mecz Arty firing Btry.							
	5	Per Mecz Arty Bn Hq.							
	7								

2480						
2500						
2520						
2540						
2560						
2580						
2600						
2620						
2640						
2660						
2680						
2700						
2720						
2740						
2760						
2780						
2800						
2820						
2840						
2860						
2880						
2900						
2920						
2940						
2960						
2980						
3000						
3020						
3040						
3060						
3080						

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215031°—40 (Face p. 128)



Channel Number	SCR-194		SCR-195	
	Frequency (mc)	Coil C-174	Coil C-175	Frequency (mc)
1	27.70	=====		52.80
2	28.20	=====		53.30
3	28.70	=====		53.80
4	29.20	=====		54.30
5	29.70	=====		54.80
6	30.20	=====		55.30
7	30.70	=====		55.80
8	31.20	=====		56.30
9	31.70	=====		56.80
10	32.20	=====		57.30
11	32.70	=====		57.80
12	33.20	=====		58.30
13	33.70	=====		58.80
14	34.20	=====		59.30
15	34.70	=====		59.80
16	35.20	=====		60.30
17	35.70	=====		60.80
18	36.20	=====		61.30
19	36.70	=====		61.80
20	37.20	=====	=====	62.30
21	37.70	=====	=====	62.80
22	38.20	=====	=====	63.30
23	38.70	=====	=====	63.80
24	39.20	=====	=====	64.30
25	39.70	=====	=====	64.80
26	40.20	=====	=====	65.30
27	40.70	=====	=====	65.80
28	41.20	=====	=====	
29	41.70	=====	=====	
30	42.20	=====	=====	
31	42.70	=====	=====	
32	43.20	=====	=====	
33	43.70	=====	=====	
34	44.20	=====	=====	
35	44.70	=====	=====	
36	45.20	=====	=====	
37	45.70	=====	=====	
38	46.20	=====	=====	
39	46.70	=====	=====	
40	47.20	=====	=====	
41	47.70	=====	=====	
42	48.20	=====	=====	
43	48.70	=====	=====	
44	49.20	=====	=====	
45	49.70	=====	=====	
46	50.20	=====	=====	
47	50.70	=====	=====	
48	51.20	=====	=====	
49	51.70	=====	=====	
50	52.20	=====	=====	

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FIGURE 2.—Operating channels, radio sets SCR-194 and SCR-195.

■ 131. SOURCES OF TECHNICAL INFORMATION.—*a. Signal Corps General Catalog.*—Some technical information on all radio sets is presented in the Signal Corps General Catalog.

*b. Technical Regulations.*

Set SCR-	TM	Set SCR-	TM
AA-183}	*TM 11-200	189}	*TM 11-270
AA-192}-----		190}-----	
134-----	*TM 11-201	194}	*TM 11-238
136-----	*TM 11-230	195}-----	*TM 11-239
178}	*TM 11-231	203-----	
179}-----		210-A)	*TM 11-272
132-A-----	*TM 11-233	245-A)	
171-----	*TM 11-234	245-B)	
163-----	*TM 11-235	245-C)	
163-A-----	*TM 11-236	245-D)	
131}	*TM 11-237		
161}-----			

*c. Instruction books.*—Instruction books which are issued with each standard radio set, when Technical Manuals therefor are not available, contain sufficient technical information to cover the installation, maintenance, and repair of the sets to which they pertain.

■ 132. TYPE RADIO NETS.—Information on typical radio nets and the type of set employed in each are covered in the other manuals in the 11-series.

## SECTION IV

### WIRE LINES

■ 133. PURPOSE.—The purpose of this section is to furnish in concise form technical information on various types of wire lines to assist in planning for, constructing, and maintaining wire lines in the theater of operations. Much of the technical data is furnished in tabular form, and more detailed information on any particular item may be found elsewhere in this manual or in FM 24-5.

■ 134. RATES OF CONSTRUCTION.—*a. Field wire line.*—Construction unit—1 wire-laying team. (See FM 11-10 and 11-15.)

\*See Appendix.





Wire laying equipment	Miles per hour			
	One circuit		Two circuits concurrently	
	Cross country	Roads	Cross country	Roads
Reel cart RL-16.....	1	1½	1	1½
Carrier RL-24, RL-24-A, or RL-34.....	1½	2	-----	-----
Reel unit RL-26 or RL-26-A (mounted in truck).....	3-5	3-5	3-5	3-5
Axle RL-27 or RL-27-A.....	1	1½	-----	-----
Reel unit RL-31 (mounted in truck).....	3-5	3-5	-----	-----

**b. Open wire pole line.**—Construction unit—1 construction platoon of war strength construction company. (See FM 11-20.)

Type of construction	Wire	Weight of material in pounds per mile	Number of poles per mile	Miles per 8-hour day <sup>1</sup>
Iron pole line, 1 circuit on cross arm and single wire on top of pole.	W-73 (No. 17 bronze).	6,420	70	3
Iron pole line, 2 circuits on cross arms and single wire on top of pole.	W-73 (No. 17 bronze).	7,042	70	2½
Light pole line, 3 circuits on 6-pin cross arm. (Light 20-foot poles or 4 by 4's with 2 by 4's for cross arms with knob insulators.)	W-73 (No. 17 bronze).	5,093	38	2½
Standard pole line, 5 circuits on 10-pin cross arm. Poles to be serviced and set, using earth boring machine.	W-74 (No. 10 copper).	11,590	40	2
Stringing wire on installed poles—addition of 1 10-pin cross arm and 5 circuits.	W-74 (No. 10 copper).	3,598	40	5
Single-bracket line on installed poles..	W-74 (No. 10 copper).	466	40	20

<sup>1</sup> The rate at which open wire lines may be constructed will depend upon the size of the working party, the number of circuits required, the weather, and the type of terrain, but most of all on the facilities for distributing poles and materials; and the chief factor in this is the question of transportation and road congestion. The data listed above are based on the assumption that the poles and material have been distributed along the route and that average conditions prevail. If poles and material have not been distributed, the time necessary to transport them from their place of storage to the locations at which they are to be installed, with due weight given to the factors mentioned above, must be considered in making an estimate of the total time it will take to build a given line.

■ **135. NORMAL TALKING RANGE ON WIRE CIRCUITS.**—Using standard equipment without repeaters, the normal talking ranges on nonloaded wire circuits are as follows (see par. 136) :

135-136 MISSION, FUNCTIONS, AND SIGNAL COMMUNICATION

Wire	Loss in decibels per mile	Range in miles	Weight, pounds per mile	Remarks
W-38.....	1.70	18	240	Commercial outside distributing wire. No. 17 AWG bronze, 8-inch spacing, dry weather.
W-73.....	.55	50.75	39	
W-74.....	.07	200	166	Commercial bare copper No. 10 AWG, 12-inch spacing, wet weather.
W-108.....	1.70	18	216	Commercial parallel drop wire.
W-110.....	2.00	15	132	Dry weather.
W-110.....	3.00	10	132	Wet weather.
W-110-B.....	1.77	17	132	Dry weather.

■ 136. WIRE EQUIPMENT, CHARACTERISTICS.

Item	Type	Loss, decibels <sup>1</sup>	Range, miles <sup>2</sup>	Weight, pounds	Remarks
Telephone.....	EE-4...	0.40	1/5	18	Monocord, 4 drop.
Do.....	EE-5.....	.40	1/5	11	
Do.....	EE-8.....	.40	1/5	10	
Do.....	EE-8-A..	.40	1/5	10	
Switchboard.....	BD-9.....	.50	1/4	10	Monocord, 12 drop.
Do.....	BD-11...	.50	1/4	20	
Do.....	BD-14...	.50	1/4	250	Local battery switchboard, 40 lines, 8 cord circuits.
Do.....	BD-71...	.50	1/4	48	Monocord, 6 drop, built in operator set and 2 repeating coils.
Do.....	BD-72...	.50	1/4	68	Monocord, 12 drop, built in operator set and 4 repeating coils.
Test set.....	EE-65...	.40	1/5	14	Universal test set for use at small exchanges.
Coil, repeating.	C-75.....	.8	2/5	4	Repeating coil for simplex-ing lines.
Do.....	C-161...	.8	2/5	3½	Do.
Coil, loading..	C-114.....	-----	-----	1½	See note 3.
Reel.....	DR-4.....	-----	-----	22	Holds 2,400 feet wire W-110; weighs 82 pounds when filled.
Do.....	DR-5.....	-----	-----	34	Holds 1 mile wire W-110; weighs 166 pounds when filled.
Repeater, commercial.	-----	{ -5.0 to -10.0 }	-----	-----	Minus decibels loss indicates gain.

<sup>1</sup>The unit employed for measuring the transmission loss or gain of a wire line with its installed equipment is the *decibel* (db). For satisfactory operation, the transmission loss of a wire line with its installed equipment should not exceed 30 db at a frequency of 1,000 cycles per second. This table shows for each item of equipment the loss in db and for each type wire the loss in db per mile of line.

<sup>2</sup>This table shows for each item of equipment the approximate equivalent loss in miles of line using wire W-110, when 1 piece of that equipment is bridged on a line.

<sup>3</sup>No figures on gain for loading coil C-114 can be given, since gain depends upon condition of line, length of line, number of coils used, and spacing of coils. Coils should be placed 1 mile apart along the line and when so used increase the talking range about 33 percent. Loading coils C-114 should never be used on a line of less than 4 to 5 miles in length.

■ 137. CHARACTERISTICS OF STANDARD TYPES OF OPEN-WIRE TELEPHONE CIRCUITS AT 1,000 CYCLES PER SECOND.

Type of circuit	Gage of wires (mils)	Spacing wires (inches)	Constants per loop mile				Line impedance		Velocity, miles per second W	Transmission equivalent, decibel per mile
			R ohms	L henrys	C mf.	G m.mho	R ohms	X ohms		
Nonpole pair side.....	165	12	4.11	0.00337	0.00915	0.29	610	57	179,500	0.0300
Pole pair side.....	165	18	4.11	.00364	.00863	.29	651	57	178,000	.0282
Nonpole pair phantom..	165	12	2.06	.00208	.01514	.58	372	28	177,500	.0250
Pole pair phantom.....	165	18	2.06	.00207	.01563	.58	365	28	177,500	.0254
Nonpole pair physical..	165	8	4.11	.00311	.00996	.14	562	58	179,000	.0321
Nonpole pair side.....	128	12	6.74	.00353	.00871	.29	643	94	178,500	.0462
Pole pair side.....	128	18	6.74	.00380	.00825	.29	686	93	177,000	.0436
Nonpole pair phantom..	128	12	3.37	.00216	.01454	.58	398	47	177,000	.0386
Pole pair phantom.....	128	18	3.37	.00215	.01501	.58	382	46	174,800	.0383
Nonpole pair physical..	128	8	6.74	.00327	.00944	.14	596	94	178,000	.0494
Nonpole pair side.....	104	12	10.15	.00366	.00837	.29	677	141	177,000	.0660
Pole pair side.....	104	18	10.15	.00393	.00797	.29	717	139	175,500	.0624
Nonpole pair phantom..	104	12	5.08	.00223	.01409	.58	415	71	176,000	.0556
Pole pair phantom.....	104	18	5.08	.00222	.01454	.58	397	69	173,600	.0565
Nonpole pair physical..	104	8	10.15	.00340	.00905	.14	629	141	175,500	.0704

## NOTES

- All values are for dry weather conditions and nonloaded circuits.
- All capacity values assume a line carrying 40 wires.
- Resistance values are for temperature of 20° C. (68° F.).
- DP insulators assumed for all 12 inch and 18 inch spaced wires; CS insulators assumed for all 8 inch spaced wires.

■ 138. CHARACTERISTICS OF STANDARD TYPES OF PAPER-INSULATED CABLE TELEPHONE CIRCUITS AT 1,000 CYCLES PER SECOND.

Type of circuit	Wire gage (AWG)	Type of loading	Spacing of load coils, miles	Constants assumed to be distributed per loop-mile				Line impedance		Cut-off frequency (approximate)	Transmission equivalent, decibel per mile
				R ohms	L henrys	C mf.	G m. mho	R ohms	X ohms		
Side.....	19	N. L. S.	.....	85.8	0.001	0.062	1.5	344.9	319.4	.....	1.08
Do.....	19	H-31-S	1.135	88.4	.028	.062	1.5	692.1	162.7	6670	.56
Do.....	19	H-44-S	1.135	89.7	.040	.062	1.5	815.6	139.6	5600	.48
Do.....	19	H-172-S	1.135	97.8	.152	.062	1.5	1,568.0	77.10	2800	.28
Do.....	19	H-174-S	1.135	102.7	.154	.062	1.5	1,578.0	81.20	2800	.29
Do.....	19	H-245-S	1.135	107.3	.217	.062	1.5	1,873.0	69.96	2400	.26
Do.....	19	M-174-S	1.66	97.4	.106	.062	1.5	1,311.3	93.1	2400	.33
Do.....	16	N. L. S.	.....	42.1	.001	.062	1.5	250.9	215.39	.....	.73
Do.....	16	H-31-S	1.135	44.7	.028	.062	1.5	677.5	83.45	6670	.29
Do.....	16	H-44-S	1.135	46.0	.040	.062	1.5	806.5	71.69	5600	.25
Do.....	16	H-172-S	1.135	54.1	.152	.062	1.5	1,566.7	41.25	2800	.16
Do.....	16	H-174-S	1.135	59.0	.154	.062	1.5	1,577.0	45.01	2800	.17
Do.....	16	H-245-S	1.135	63.6	.217	.062	1.5	1,872.0	40.02	2400	.16
Do.....	16	M-174-S	1.66	53.7	.106	.062	1.5	1,311.1	50.06	2400	.19
Do.....	13	N. L. S.	.....	21.9	.001	.062	1.5	193.5	145.2	.....	.49
Do.....	13	H-245-S	1.135	47.9	.217	.062	1.5	1,871.0	29.3	2400	.12
Do.....	13	M-174-S	1.66	38.6	.106	.062	1.5	1308.0	35.36	2400	.14
Phantom.....	19	N. L. P.	.....	42.9	.0007	.100	2.4	194.8	175.23	.....	.96
Do.....	19	H-18-P	1.135	44.2	.017	.100	2.4	420.9	82.98	6990	.46
Do.....	19	H-25-P	1.135	44.8	.023	.100	2.4	485.3	72.59	5900	.41
Do.....	19	H-63-P	1.135	48.4	.056	.100	2.4	750.3	49.96	3700	.29
Do.....	19	H-106-P	1.135	50.9	.094	.100	2.4	970.6	39.92	2900	.24
Do.....	19	H-155-P	1.135	53.8	.137	.100	2.4	1,171.1	34.45	2400	.21
Do.....	19	M-106-P	1.66	48.4	.065	.100	2.4	807.6	46.09	2400	.27
Do.....	16	N. L. P.	.....	21.0	.0007	.100	2.4	143.7	116.29	.....	.65
Do.....	16	H-18-P	1.135	22.3	.017	.100	2.4	405.4	43.04	6990	.24
Do.....	16	H-25-P	1.135	22.9	.023	.100	2.4	481.2	36.97	5900	.21
Do.....	16	H-63-P	1.135	26.5	.056	.100	2.4	748.9	26.74	3700	.16
Do.....	16	H-106-P	1.135	29.0	.094	.100	2.4	970.0	21.96	2900	.14
Do.....	16	H-155-P	1.135	31.9	.137	.100	2.4	1,171.0	19.48	2400	.13
Do.....	16	M-106-P	1.66	26.5	.065	.100	2.4	806.6	24.62	2400	.15
Do.....	13	N. L. P.	.....	10.9	.0007	.100	2.4	113.5	76.32	.....	.43
Do.....	13	H-155-P	1.135	23.9	.137	.100	2.4	1,170.2	14.03	2400	.10
Do.....	13	M-106-P	1.66	18.3	.065	.100	2.4	806.5	16.54	2400	.11
Physical.....	16	B-22	0.568	43.1	.040	.062	1.5	806.3	67.10	11000	.24

## NOTES

a. *Type of loading*.—(1) First letter indicates loading coil spacing intervals:

H.....feet..... 6,000

M.....do..... 8,800

B.....do..... 3,000

(2) Number indicates inductance of loading coil in millihenrys.

(3) Second letter indicates whether coil is for use on a side or phantom circuit.

(4) N. L. S. indicates no loading on the side circuit.

b. Loading coil C-63 corresponds to M-174-S.

### ■ 139. RELATION BETWEEN DECIBELS AND POWER RATIOS FOR GAINS AND LOSSES.

Decibels	Approximate ratio power output—for losses		Power input—for gains, decimal	Decibels	Approximate ratio power output—for losses		Power input—for gains, decimal
	Fraction	Decimal			Fraction	Decimal	
1.....	$\frac{4}{5}$	0.80	1.25	7.....	$\frac{1}{5}$	.20	5.0
2.....	$\frac{2}{3}$	.67	1.6	8.....	$\frac{1}{6}$	.17	6.0
3.....	$\frac{1}{2}$	.50	2.0	9.....	$\frac{1}{9}$	.125	8.0
4.....	$\frac{3}{5}$	.40	2.5	10.....	$\frac{1}{10}$	.10	10.0
5.....	$\frac{2}{3}$	.33	3.2	20.....	$\frac{1}{100}$	.01	100.0
6.....	$\frac{1}{4}$	.25	4.0	30.....	$\frac{1}{1000}$	.001	1,000.0

NOTE.—Above data computed from—

$$\text{Number of db} = 10 \log_{10} \frac{P \text{ output}}{P \text{ input}} = 20 \log_{10} \frac{I \text{ output}}{I \text{ input}}$$

■ 140. METHODS OF CONSTRUCTION AND MAINTENANCE.—The construction and maintenance of field wire lines are completely covered in FM 24-5. Open wire line, aerial cable, and buried cable construction and maintenance conform with standard commercial practices. Sets of suitable specifications covering commercial construction and maintenance are issued to units concerned.

## SECTION V

### LOCAL BATTERY TELEPHONE EQUIPMENT

■ 141. PURPOSE.—The purpose of this section is to cover briefly the technical features of local battery telephone systems and equipment employed in the theater of operations which are not completely covered in other War Department publications.

■ 142. EQUIPMENT IN GENERAL.—*a. Standard.*—The following standard military local battery telephone equipment is completely covered in the publications indicated:

(1) Telephone EE-8—\*TM 11-332; telephone EE-8-A—TM 11-333.

(2) Switchboards BD-71 and BD-72—\*TM 11-330.

\*See Appendix.

(3) Switchboard BD-14—\*TM 11-331.

(4) Test set EE-65—\*TM 11-361.

*b. Limited standard.*—The following limited standard military equipment may remain in use for some time and is covered in FM 24-5:

(1) Telephone EE-4.

(2) Telephone EE-5.

(3) Switchboards BD-9 and BD-11.

■ 143. LOCAL BATTERY TELEPHONES.—*a. Component parts.*—

The components of the local battery telephone are the receiver, transmitter, induction coil, hand generator or magneto, ringer, hook switch, and battery.

(1) *Receiver.*—The following technical data are applicable to all receivers:

(a) The pull on the diaphragm exerted by the permanent magnet should be approximately 20 ounces. A convenient way of testing this pull is shown in figure 4. The magnets should hold the diaphragm in this position.

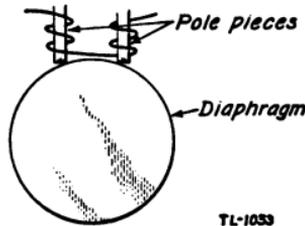


FIGURE 4.—Strength test of receiver magnet.

(b) Clearance between diaphragm and pole pieces should be about 0.02 inch.

(c) Diaphragm should always be placed with the brown side toward the pole pieces.

(d) Windings on receivers of the same type should have approximately the same d. c. resistance. An appreciable variation on any one receiver is an indication of trouble. The d. c. resistance of the telephone receiver WE 144 in common use on local battery systems is 80 ohms. Special high resistance watch case receivers used on test boards have a d. c. resistance of 500 ohms.

(e) Permanent magnet of receiver may be damaged by jarring or by connecting the receiver so that direct current

\*See Appendix.

flow through the windings establishes a magnetic field in opposition to that of the permanent magnet. For information on properly connecting a receiver through which direct current will flow, see FM 24-5.

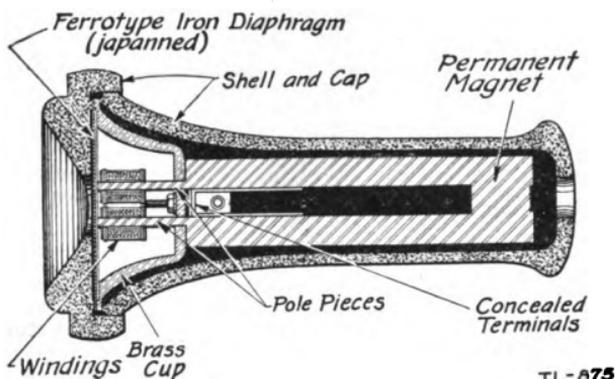


FIGURE 5.—Telephone receiver.

(f) Some of the troubles encountered in receivers are as follows:

1. Bent diaphragm.
2. Rust or dirt on pole pieces preventing motion of the diaphragm, or weak permanent magnet.
3. Incorrect clearance or gap between diaphragm and pole pieces.
4. Loose diaphragm.
5. Open winding.
6. Open receiver cord.

(2) *Transmitter*.—The following technical data are applicable to all solid back, carbon granule telephone transmitters (see fig. 6):

(a) The resistance of the transmitter at rest is about 50 ohms.

(b) In use the transmitter should be held with the diaphragm vertical.

(c) Transmitter troubles and the most frequent cause of each are listed below:

1. *Resonating*.—A fault of construction and rarely encountered.
2. *Rattling*.—Caused by a loose diaphragm, loose contact with transmitter button at the center of the

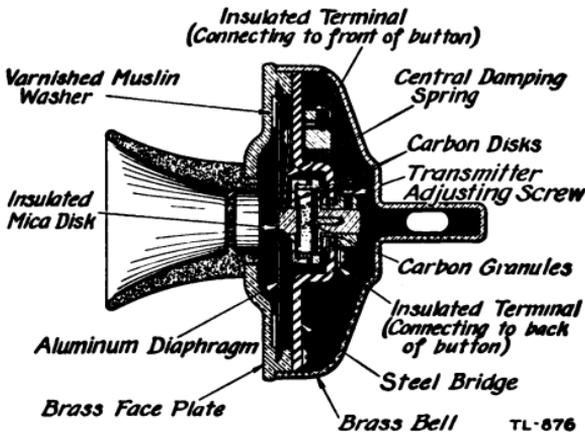


FIGURE 6.—Solid back, carbon granule transmitter.

diaphragm, or a loosening of the transmitter adjusting screw.

3. *Heating*.—Caused by excessive current through the transmitter. This pits the carbon granules and gives rise to packing.
4. *Packing*.—Caused by broken granules or dust in the carbon button. A frying noise in the receiver usually is an indication of heating or packing. In a packed transmitter the granules are stuck together, and vibrations of the diaphragm cannot vary the contact resistance.

(3) *Induction coil*.—The induction coil is provided in local battery telephones in order to remove the line and receiver resistance from the battery and transmitter circuit. It is a transformer which is efficient over a wide range of voice frequencies. The following data are applicable to a common type of induction coil used in local battery telephony and may be used as an indication of what may be expected to be normal values of the constants:

	Primary winding	Secondary Winding
Resistance.....ohms.....	1.8	22
Number of turns.....	400	1,700

The step up ratio is therefore 1 to 4¼.

(4) *Magneto.*—(a) *General.*—The magneto on a local battery telephone consists of an armature which may be rotated manually in a magnetic field which is established by U-shaped steel permanent magnets. When the operating crank is turned at normal speed, the magneto develops an electromotive force of 85 to 90 volts at a frequency of 17 to 20 cycles. On all types of magnetos the product of the number of turns on the armature times the number of separate U magnets which establish the field is approximately constant and is equal to about 8,700.

(b) *Troubles.*—The following troubles may develop on magnetos used on local battery telephone circuits:

1. Open armature winding.
2. Mechanical derangement of rotating parts.
3. Maladjustment of, or dirty contacts on, the automatic switch at end of armature shaft.
4. Weak permanent magnets.

(5) *Ringer.*—The following technical data are applicable to telephone ringers:

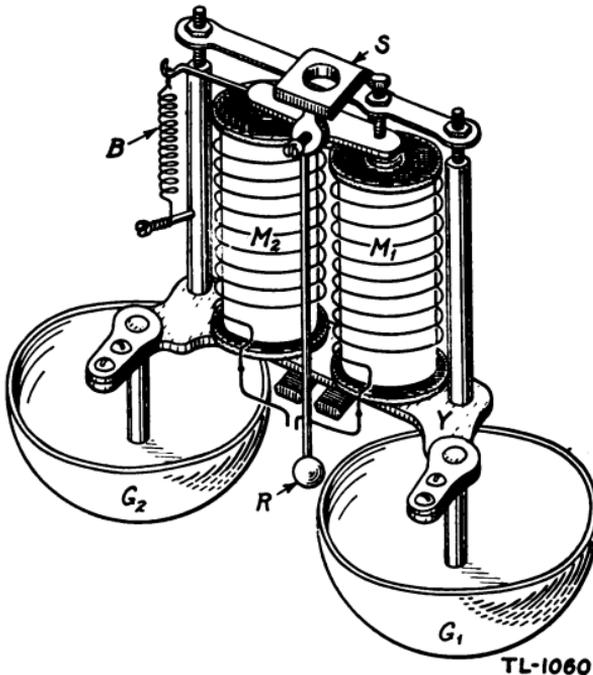


FIGURE 7.—Telephone ringer.

(a) Ringer resistances vary from 250 to 2,500 ohms, but the most common type has a resistance of 1,000 ohms.

(b) The impedance of the 1,000-ohm ringer to voice frequency currents is approximately 30,000 ohms. A ringer may therefore be left across the telephone line during conversation without causing material transmission loss.

(c) The following troubles develop on telephone ringers:

1. Open ringer winding,  $M_1$ - $M_2$ .
2. Maladjustment of tapper rod R and gongs  $G_1$  and  $G_2$ . (See fig. 7.)
3. Biasing spring B too loose or missing.

(6) *Hook switch*.—(a) *General*.—A hook switch is provided on local battery telephones to open the transmitter battery circuit and the line circuit at the receiver side of the telephone ringer. This prevents consumption of battery when the telephone is not in use and prevents the bypassing of ringing currents through the low impedance receiver when the instrument is being signaled. (See fig. 8.)

(b) *Troubles*.—The most general troubles encountered on the hook switch are—

1. Dirty contacts—indicated by a frying noise when the telephone is in use.
2. Maladjustment of the spring leaves of the switch.

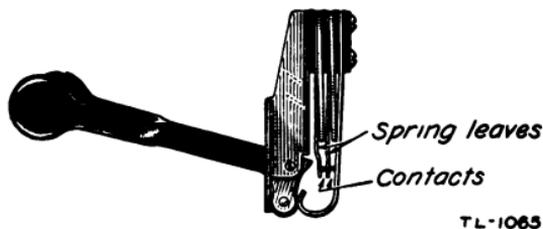


FIGURE 8.—Hook switch.

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(7) *Circuit diagrams*.—Circuit diagrams of typical commercial local battery telephones are indicated in figures 9 and 10.

b. *Location of faults*.—(1) *Preliminary*.—If trouble is reported from a local battery telephone, first make sure that the trouble is in the telephone and not in the line or inside wiring. Do this by removing the telephone from the line and then by calling the exchange with a test telephone from the

line terminals. If the fault is in the telephone, the tests following will quickly localize the trouble.

(2) *Ringing circuit.*—With the receiver on the hook, put the fingers on the line terminals  $L_1$  and  $L_2$  of the telephone and turn the magneto  $M$ . If ringing current is felt, the magneto circuit is functioning properly. If no ringing current is felt and the magneto turns easily, the trouble is an open.

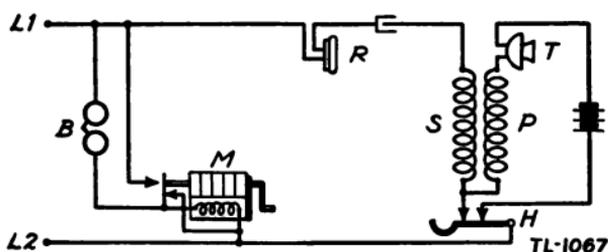


FIGURE 9.

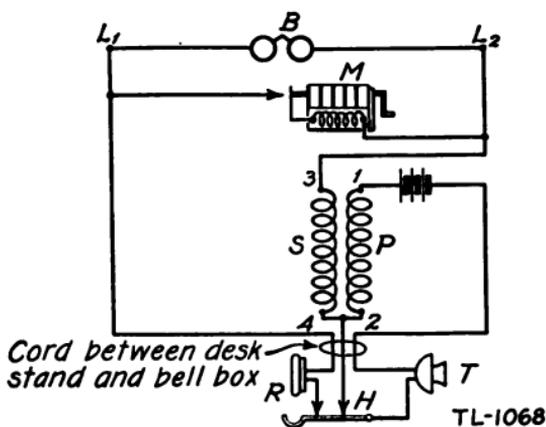


FIGURE 10.

Try the fingers on the magneto terminals while the magneto is turned, and if no ringing current is felt the magneto switch may need adjustment. If after such adjustment no ringing current is felt, the magneto must be replaced. If the ringing current is felt at the magneto terminals, but not at the line terminals, there is an open between the magneto and line terminals. If the magneto turns hard and no current is felt, the trouble is a short. Disconnect the line and repeat the test. If the ringing current is now felt, the fault is a short on the line, and if no ringing current is felt the short is in the

telephone, probably in the hook switch H. If the ringer B is connected directly across the line terminals (fig. 10) the bells will ring in the above test, proving that the ringer circuit is operative; if they do not ring, but ringing current is felt, the fault is an open in the ringer circuit.

(3) *Secondary talking circuit.*—The next test is to hold the receiver R to the ear and turn the magneto, assuming that any fault found hitherto has been repaired. If the ringing current is heard in the receiver, the secondary circuit S of the telephone is operative. If the ringing current is not heard, see that the hook switch is making contact; next test the receiver and cord for an open. An open secondary of the induction coil will be indicated by hearing the ringing current when the secondary terminals have been shorted and the magneto is turned.

(4) *Primary talking circuit.*—With the receiver to the ear, blow into the transmitter T; a rustling sound should be heard in the receiver. If it is not, test the battery and replace it if necessary. If the primary circuit still fails to function properly, see if the hook switch contacts make. Then test for an open or packed transmitter by shorting the transmitter; a faulty transmitter will be indicated by clicks in the receiver when the transmitter terminals are shorted. Look for broken wires, and last of all replace the induction coil.

*c. Installation and maintenance.* (See par. 148 c and d.)

■ 144. LOCAL BATTERY TELEPHONE SWITCHBOARD.—*a. Circuits.*—The circuits on a telephone switchboard are classified as line circuits, cord circuits, and miscellaneous circuits.

(1) *Line circuit.*—The components of the line circuit on a local battery switchboard are the line drop and the line jack.

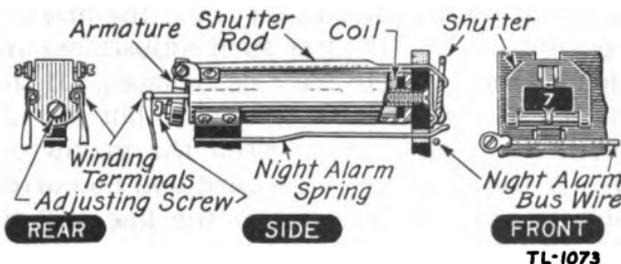


FIGURE 11.—Line drop.

(a) *Line drop*.—The resistance of different types of drops varies from 80 to 1,600 ohms—the greater the resistance, the more sensitive the drop. The following features of the drop are noteworthy:

1. The armature hangs between pointed pivot screws provided with lock nuts, and by means of these, end play can be taken out of the bearings.

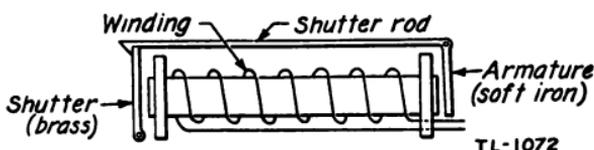


FIGURE 12.—Schematic diagram of a line drop.

2. The winding terminals are at the rear of the drop, permitting the armature to be adjusted, the coil to be removed, or wire connections to be resoldered without disturbing the operator.
3. The armature when attracted cannot make contact with the magnet core, thus it will not stick in the operated position.
4. The shutter rod is slightly bent near its hooked end where it passes through a hole in the shutter (fig. 12), so that when the armature is attracted, the inclined upper face of the rod strikes the upper edge of the hole in the shutter forcing the shutter outward and accelerating its fall.

(b) *Line jack*.—Figure 13 illustrates one type of line jack. A plug is shown inserted in the jack. Figure 14 shows the

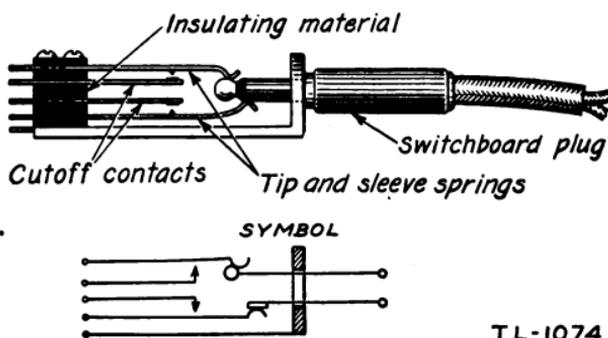


FIGURE 13.—Line jack.

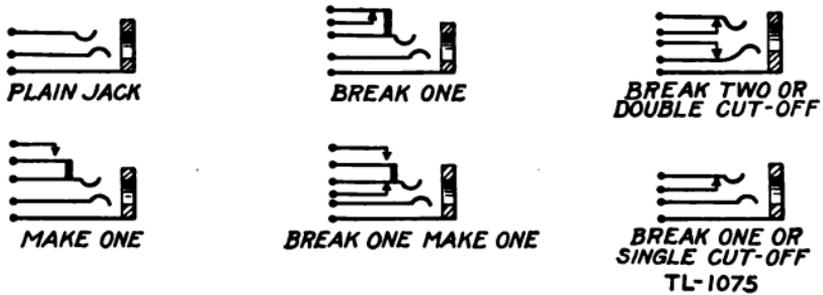


FIGURE 14.—Symbols of switchboard jacks.

symbols of a number of jacks that are used with a statement of the function that each performs. Line jacks are often integral parts of the line drops with which they are associated. Proper maintenance of line jacks requires that all contact surfaces be clean and bright. Spring leaves which carry auxiliary contacts must be adjusted so that the function of making or breaking contacts as the plug is inserted in the jack is properly carried out.

(2) *Cord circuit.*—The cord circuit on a switchboard terminates in plugs, the insertion of which into line jacks allows direct connection between the telephone lines which terminate at the jacks. An operator's telephone and a magneto which may be connected by means of keys across any one of the several cord circuits on the board permit an operator to signal and talk to any subscriber. A circuit diagram of a typical cord circuit for use on a local battery switchboard is shown

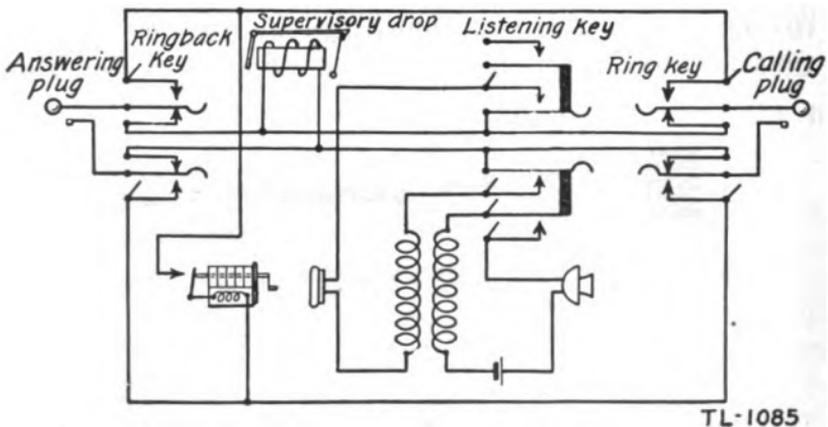


FIGURE 15.—Local battery cord circuit.

in figure 15. Points common to all cord circuits are indicated by means of short oblique lines.

(3) *Miscellaneous circuits.*—(a) *Night alarm circuit.*—This circuit is found on every switchboard. Its purpose is to give an audible signal every time either a line or supervisory drop is

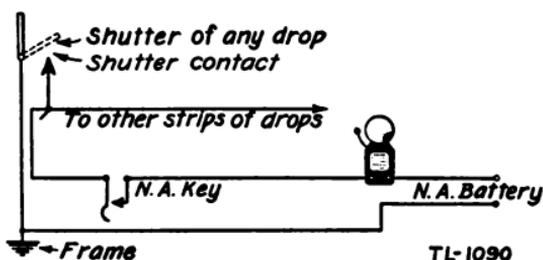


FIGURE 16.—Night alarm circuit.

operated. Trouble experienced with this circuit is generally associated with the parallel connected contacts one of which should close each time the shutter on a line or supervisory drop falls. (Fig. 16.)

(b) *Generator switching circuit.*—A generator switching key enables the operator to change from one source of ringing current to another. Diagram of the circuit arrangement is shown in figure 17.

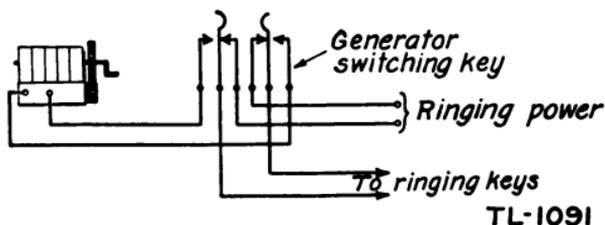


FIGURE 17.—Generator switching circuit.

(c) *Through trunk circuit.*—When use of a trunk circuit is desired at an intermediate telephone central through which it passes, this trunk may be connected through the switchboard of the intermediate central by means of the through trunk circuit illustrated in figure 18. To signal the intermediate central, code ringing is used.

(d) *Special trunk circuits.*—Frequently a local battery switchboard is connected to lines which terminate at a com-

mon battery switchboard. Unless the common battery switchboard is especially equipped to handle local battery lines, it will be necessary to modify the line circuits on the local battery switchboard. This modification is required to facilitate signaling of the common battery switchboard and to

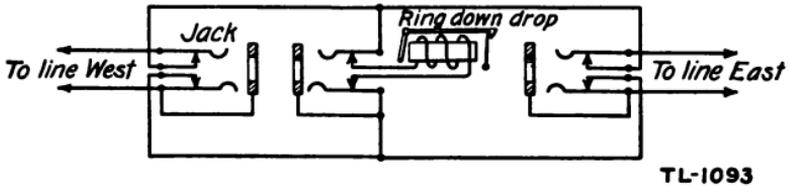


FIGURE 18.—Through trunk circuit.

prevent false supervision. One method of accomplishing this modification is shown in figure 19.

(e) *Interposition trunk circuits.*—In some cases where several local battery switchboards are grouped together as positions of one large switchboard, each position is equipped with trunk circuits to each other position. This enables a line on one position to be connected to a line on any other position. These trunks are unnecessary between adjacent switchboards when the cords of each are sufficiently long to reach the other.

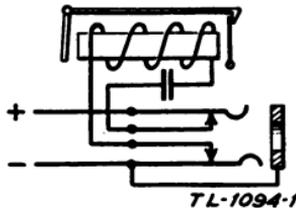


FIGURE 19.—Modified line circuit for trunk use.

(f) *Transfer circuits.*—When a single operator is handling a two or three position switchboard, occasions may arise which necessitate the use of cord circuits at positions other than the one from which he is operating the board. To permit the use of cord circuits at other positions in conjunction with the operator's telephone at his own position a transfer circuit is required. A circuit diagram of a transfer circuit found on many switchboards is shown in figure 20.

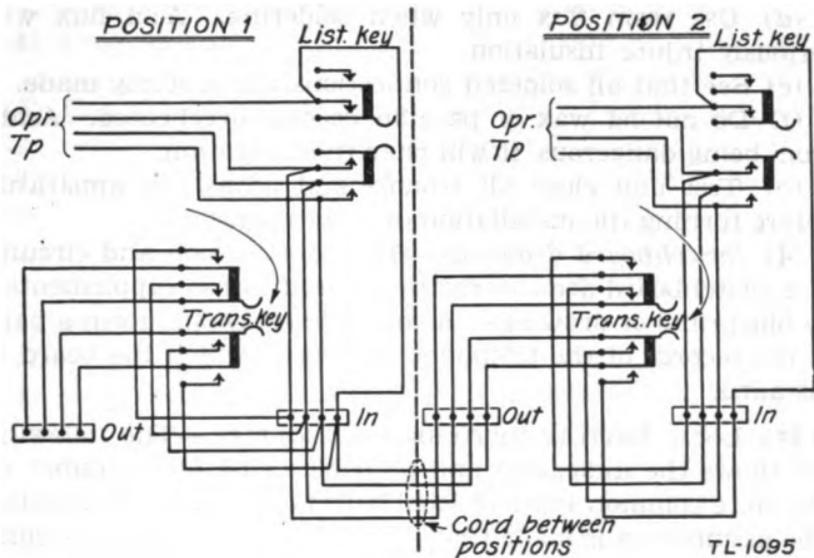


FIGURE 20.—Transfer circuit.

*b. Installation.*—(1) *Setting up the switchboard.*—Fit the positions or sections together and level the switchboard, shimming where necessary. Secure the switchboard firmly in place by bolts or screws. Mount the cable racks leading to frames. (See par. 156.) Mount the apparatus and wire the circuits as called for in the drawings and specifications.

(2) *Cable forms and wiring.*—Run the wiring of all switchboards as far as possible in cable forms and in accordance with a definite color scheme, so that any wire can be readily identified in any part of the switchboard. Individual wiring in local or line cables and forms is No. 22 B and S double silk and cotton insulated copper wire. Common circuit wiring is of No. 20 B and S black enameled double silk and cotton insulated copper wire. Boil all forms in beeswax to drive out moisture, increase insulation, and prevent fraying of the silk and cotton insulation.

(3) *Important points to remember:*

- (a) Handle all switchboard apparatus carefully.
- (b) Do all work neatly.
- (c) Never splice a switchboard cable unless it is unavoidable. Be certain of your measurements before cutting the cable.

(d) Use rosin flux only when soldering. Acid flux will seriously injure insulation.

(e) See that all soldered connections are properly made.

(f) Do not let wax or paraffin become overheated. Aside from being dangerous, it will char the insulation.

(g) Test and clear all trouble and adjust all apparatus before turning the installation over for operation.

(4) *Switchboard drawings.*—The construction and circuits of a switchboard are covered by a specification supplemented by blueprints or drawings. A complete set should form a part of the records of the telephone system on which the board is installed.

■ 145. LOCAL BATTERY SWITCHBOARD TROUBLES.—The following list shows the indication and probable cause of a number of the more common types of local battery switchboard troubles. The assumption is made that in each case the trouble is confined to the central.

*a. Line circuit.*

*Indications of trouble*

(1) Cannot signal or talk.

(2) Operator can signal subscriber and talk, but subscriber cannot signal operator.

(3) Can hear cross-talk.

*Probable cause*

(1) Open or short at frame. Open or short at jack.

(2) Drop out of adjustment. Open at jack or at drop. Open drop.

(3) Making contact with another circuit at frame or at jack.

*b. Cord circuit.*

*Indications of trouble*

(1) Can talk but cannot ring.

(2) Can ring but cannot talk.

(3) Talk and ring O. K., but supervisory drop does not fall.

*Probable cause*

(1) Ringing-key contact not making. Open ringing strap.

(2) Listening contact not making. Open listening strap.

(3) Drop out of adjustment. Open drop.

*Indications of trouble*

- (4) Cross-talk.
- (5) Can ring on keys 1 to 8 only.
- (6) Cannot ring on position.

*Probable cause*

- (4) Crossed at cord shelf or at repeating coils.
- (5) Open ringing strap between keys 8 and 9.
- (6) Open generator lead at ringing key or open at generator switching key. Open at ringing resistance.

*c. Operator's telephone circuit.*

*Indications of trouble*

- (1) Can hear but cannot be heard.
- (2) Can be heard but cannot hear.

*Probable cause*

- (1) Exhausted battery. Primary circuit contact not making at listening key. Open at key contacts, at induction coil, or open induction coil.
- (2) Defective receiver or open receiver circuit.

*d. Night alarm circuit.*

*Indications of trouble*

- (1) Night alarm bell does not ring.
- (2) Night alarm bell rings continuously.

*Probable cause*

- (1) Open at night alarm key, the night alarm bell, or at contact operated by shutter of line drop.
- (2) Night alarm lead to shutter contacts grounded.

SECTION VI

COMMON BATTERY TELEPHONE EQUIPMENT

■ 146. PURPOSE.—The purpose of this section is to cover briefly the technical features of standard common battery telephone systems and equipment employed in the theater of operations which are not completely covered in other War Department publications.

■ 147. EQUIPMENT IN GENERAL.—Military standardization of common battery telephone equipment has not taken place but may be expected for corps and larger units. Commercial

equipment, although varying to an appreciable extent in form and make-up of individual items, is standardized along functional lines. The technical data supplied in this section must be applied to individual pieces of commercial equipment only insofar as they pertain to the function of that equipment and to the circuit of which it is a part.

■ 148. COMMON BATTERY TELEPHONE.—*a. Components.*—(1) *General.*—The principal components of the common battery telephone are the receiver, the transmitter, the induction coil, the ringer, the capacitor, and the hook switch. The receiver, transmitter, ringer, and hook switch are generally similar to those used in local battery telephones and are described in section V. The set box may contain all of these components except the receiver, transmitter, and hook switch, and in certain types contains all of these components.

(2) *Induction coil.*—The induction coil differs somewhat from the one used in the local battery telephone. It is used to couple the receiver circuit to the transmitter circuit and makes it unnecessary to pole the receiver. In a typical common battery induction coil, the resistance of its 1-2 winding, in series with the transmitter, is 14.7 ohms. The 3-4 winding, in series with the receiver, has a resistance of 9.5 ohms. The turn ratio of the 1-2 winding to the 3-4 winding is 17 to 14.

(3) *Capacitor.*—The capacitor has the same function as the one used in the telephone EE-8 which is described in TR 1225-10. The capacity of this capacitor is 2 microfarads.

*b. Circuits.*—(1) *Fundamental circuit.*—Figure 21 shows the schematic diagram of a common battery telephone. There are three distinct circuits in this telephone as follows:

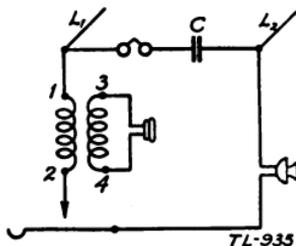


FIGURE 21.—Common battery telephone circuit.

(a) The *transmitter* circuit which comprises  $L_1$ , the 1-2 winding of the induction coil, the transmitter, and  $L_2$ .

(b) The *receiver* circuit which comprises the receiver and the 3-4 winding of the induction coil.

(c) The *ringer* circuit which comprises  $L_1$ , the ringer, the capacitor  $C$ , and  $L_2$ .

(2) *Booster circuit*.—The booster circuit illustrated in figure 22 is now used in nearly all common battery telephones. The identical parts are used as in the circuit described in (1) above, but the capacitor and transmitter are included in the receiver circuit. This is done by connecting terminal 3 of the induction coil to the point between the ringer and the capacitor and bringing one side of the receiver to a hook switch contact. By comparing figure 21 with figure 22 it can be seen just what changes in wiring are necessary to change from one to the other. The booster circuit is considerably more efficient in transmitting and only slightly less efficient in receiving than is the circuit shown in figure 21.

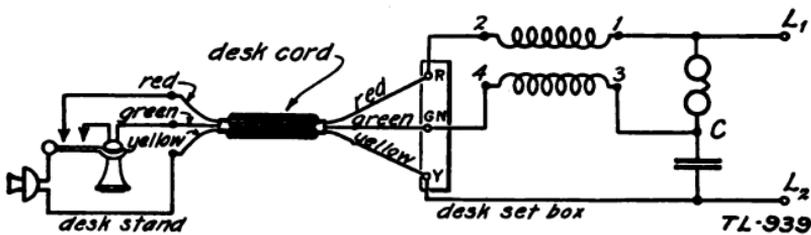


FIGURE 22.—Booster circuit.

(3) *Sidetone reduction circuit*.—When a booster telephone is used in a noisy place, the local noises affect the current in the receiver circuit. This interference or sidetone may prevent satisfactory conversation over the telephone. To reduce this interference the wiring may be changed to conform to that shown in figure 23. When so wired the booster effect is lost, so the change should not be made on telephones that are likely to be used on long distance work. Most telephones can be changed easily from one type of circuit to the other by merely interchanging the position of two wires of the cord on the terminal block. (Compare fig. 22 with fig. 23.)

*c. Installation*.—(1) *Inside wiring*.—(a) When a single party line is being installed, run a 2-conductor, 19-gage wire

from the protector to the set box. If party line service is to be rendered, run a 3-conductor, 19-gage wire from the protector to the set box, and connect the additional conductor to the ground terminal of the protector. If standard inside wire is used, connect the red tracer to the ring side of the line, the green tracer to the tip side, and the yellow tracer to ground.

(b) Make the inside wire as short as is consistent with good appearance and with the protection of the wire from mechanical injury and dampness. If it is necessary to cross light wires, tape the inside wire and do not allow it to touch the light wires.

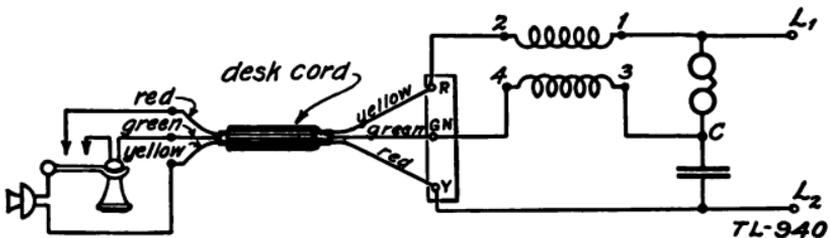


FIGURE 23.—Sidestone reduction circuit.

(2) *Protector*.—(a) Unless telephone lines entering the subscriber's premises are underground, install a protector at a point where the line enters the building which is accessible and dry and which will not expose the protector to mechanical injury. A protector consists of fuses and a lightning arrester mounted on a porcelain back. The fuses are 10-ampere fuses of special type. The lightning arrester consists of two carbon blocks separated by a piece of mica. There are two pairs of blocks in each arrester; of each pair, connect one block to one side of the line and the other block to the ground terminal of the protector.

(b) Three terminals appear at one end of the protector and two at the other end. Connect the line wires to the latter, the inside or house wiring to the outside terminals of the former three, and the ground to the middle terminal of the former three. The ground may be made on a cold-water pipe, on the street side of a gas meter, or, if neither is available a ground rod may be used. Keep the wire connecting the protector to ground as short as possible.

*d. Maintenance.*—(1) *Routine inspections.*—On a routine inspection of a telephone, replace all worn or broken parts, tighten loose connections, adjust the ringer if necessary, examine the hook switch, and screw the receiver cap on tight. If the telephone is noisy, check the receiver diaphragm to see if it is bent or corroded; if it is, replace it. Shake all cords, and if noise is thereby produced in the receiver replace the cord. Tip the transmitter down and then raise it; if a frying noise is heard in the receiver, replace the transmitter. See that all stay cords are properly tied. Then go over the inside wiring, clean the carbons in the protector, and see that the fuses are not loose. If the instrument is a local battery telephone, inspect the batteries and replace them if they are run down.

(2) *Locating troubles.*—Troubles in common battery telephones will usually be reported by the effect produced. The common troubles are given below with the procedure for locating the trouble.

(a) *Permanent signal on switchboard.*—This is due to a short either on the line or in the telephone. Remove a fuse from the protector and connect a handset across the line terminals. If the operator answers, ask if the trouble has been corrected; if it has been, the short is in the inside wiring or telephone. Go to the telephone after replacing the fuse and after determining that the short is not in the protector. Remove one line from the telephone and, with the handset, call in on the line to see if the trouble has been corrected. If it has been, the short is in the telephone; if it has not been, it is in the inside wiring. If the short is in the telephone, see that the hook switch contacts break when the receiver is on the hook; if they do, the trouble is probably a broken-down condenser.

(b) *Subscriber cannot get central.*—This may be due to a short or an open. If due to a short, a permanent signal will show on the switchboard and the procedure is as outlined in (a) above. If the trouble is an open, make sure that there is battery at the telephone terminals by testing with a handset. If there is battery at the telephone terminals, examine the hook switch for an open and look for any loose wiring.

Next, short the transmitter; an open or packed transmitter will be indicated by clicks in the receiver. If the primary of the induction coil is open, shorting the primary will call the operator.

(c) *Bells do not ring.*—The ringer may be shorted or open or the bells may not ring because they are out of adjustment. A short between the primary and secondary of the induction coil will prevent the ringer from operating.

(d) *Subscriber hears but cannot be heard.*—The transmitter is probably packed.

(e) *Subscriber cannot hear but can be heard by the operator.*—See that the hook switch is making contact. Examine the receiver cord for an open. Examine the receiver for loose contacts. Test the magnets in the receiver and see that the diaphragm is not sticking. Test the secondary of the induction coil for an open.

(f) *Circuit is noisy.*—Look for loose connections, dirty carbons, or loose fuses. Look for broken or wet cords. Check the receiver diaphragm. See if the transmitter is packed.

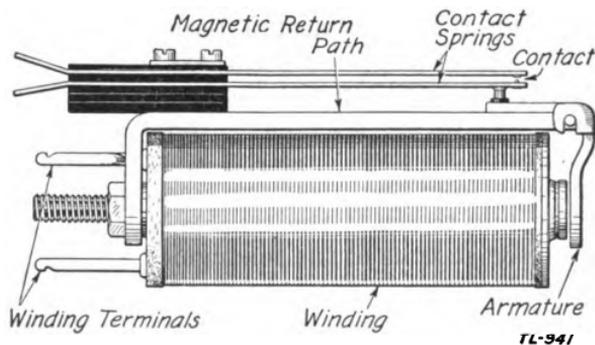


FIGURE 24.—Typical telephone relay.

■ 149. TELEPHONE RELAYS.—*a. General.*—Relays employed on common battery telephone systems vary widely in design and characteristics. Each, however, consists of an electromagnet, a magnetic return path, an armature, one or more springs actuated by the armature, and one or more contact springs. A typical relay is shown in figure 24.

*b. Classification.*—A relay is classified by the number of contacts made or broken, the function the relay performs,

its construction, the nature of its windings, or the manner of its operation.

(1) *Contacts*.—Figure 25 illustrates some of the arrangements of contacts, the terminology used to describe them, and the symbols for schematically representing these contacts.

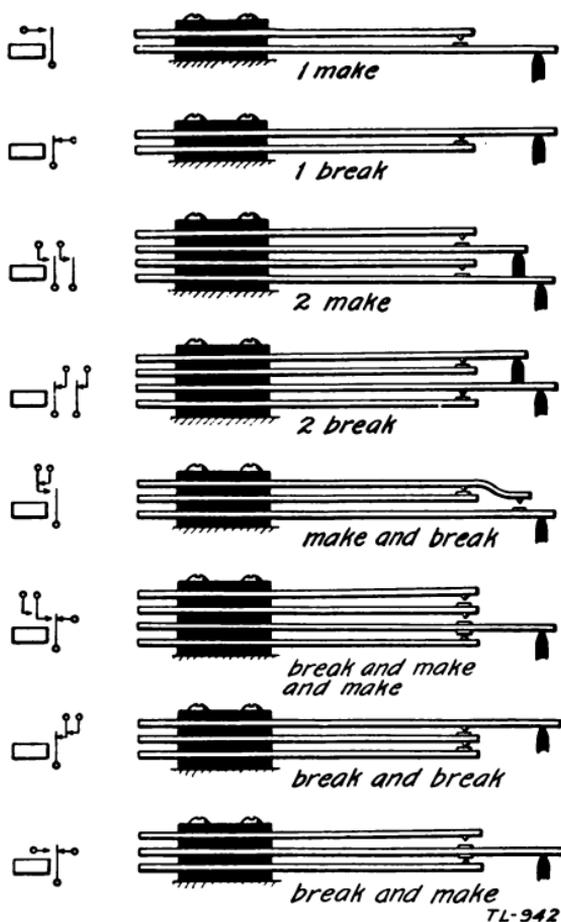


FIGURE 25.—Relay contacts.

(2) *Function*.—Based upon the function of relays, they are often referred to as line, cut-off, trunk, or supervisory relays.

(3) *Construction*.—When described with reference to their construction, relays are termed flat type, peanut, or shell type.

(4) *Windings*.—Not all relays consist of a simple single wound magnet, since the operating characteristics of some

circuits require special windings. Figure 26 shows some of the common forms of windings.

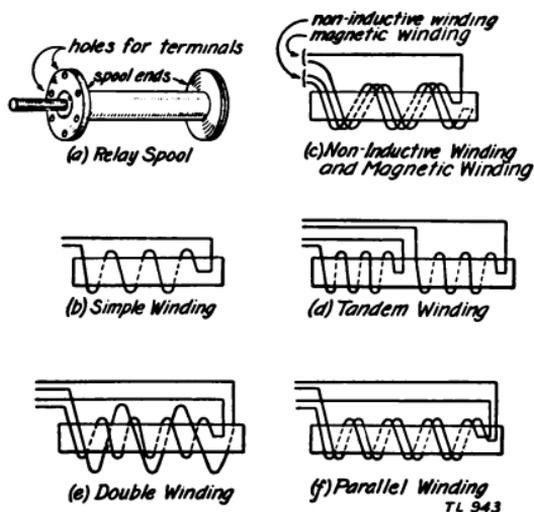
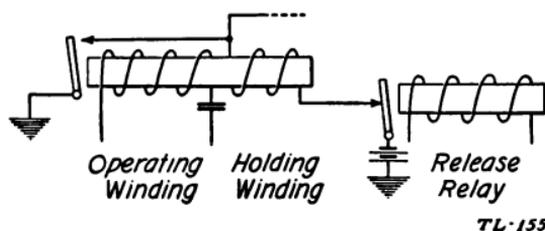


FIGURE 26.—Relay windings.

(5) *Operation.*—(a) *Marginal.*—A marginal relay pulls up when the current reaches a certain operating value, falls back and remains nonoperated as soon as the current falls off to a certain nonoperating value which is less than the operating value. For marginal operation, it is necessary to know both the operating and nonoperating values of the current and to take advantage of them in arranging the circuit.

(b) *Differential.*—A differential relay is one whose armature is released by means of a current flowing through a second winding on the relay in such a direction as to oppose the field set up by the operating current.

(c) *Holding.*—A holding relay is one which after operation by a current impulse in one circuit is held in its operated



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FIGURE 27.—Holding relay with associated release relay.

position by current in the circuit closed by its operation. This relay requires a release relay for releasing the holding device. Figure 27 illustrates a holding relay and an associated release relay.

(d) *Locking*.—A locking relay is mechanically locked into operated position when a current impulse pulls it into that position. This relay requires a trip relay for disengaging the mechanical locking device. Figure 28 illustrates a locking relay and an associated trip relay.

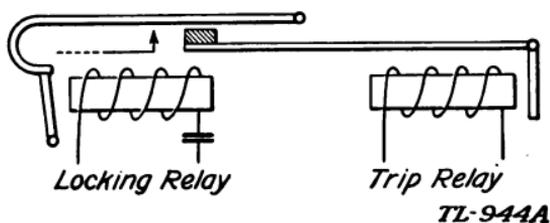


FIGURE 28.—Locking relay with associated trip relay.

(e) *Delayed acting*.—The placing of a copper slug around the winding of a relay delays the rate at which a magnetic field can change in the core under this slug. When this slug is placed only over the end away from the armature, the relay is slow to release only; if, however, the slug is placed over the winding at the armature end, it is slow to release and slow to act. The length and thickness of the copper slug determine the time delays to be expected.

c. *Cleaning and adjustment*.—The cleaning and adjustment of relays conform with standard commercial procedures. (See par. 159.)

■ 150. COMMON BATTERY SWITCHBOARDS.—a. *Line circuits*.—A line circuit on a common battery switchboard comprises that portion of the switchboard associated with an individual subscriber.

(1) *Components*.—In general the components of a line circuit are a line jack, a line signal, and one or more line relays.

(a) *Line jack*.—The contacts of a common battery jack are tip, ring, and sleeve. Tip and ring contacts are springs and the sleeve contact is tubular. Tip and ring springs afford connection for the line, and the sleeve contact affords connection to auxiliary circuits. Jacks are made in strips of

10 or 20 according to the switchboard in which used. Figure 29 illustrates both simple and cut-off jacks.

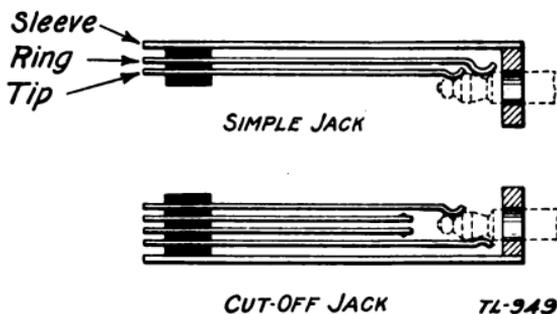


FIGURE 29.—Line jacks.

(b) *Line signal*.—The line signal is usually a small lamp. These lamps are inserted in simple 2-conductor jacks, known as lamp jacks, as shown in figure 30. The mouth of the jack is closed with a glass lamp cap or opal which may be one of a number of colors to designate the class of service given the line. Lamp jacks are built in strips of 10 or 20 and are mounted either directly above or below the line jacks with which they are associated.

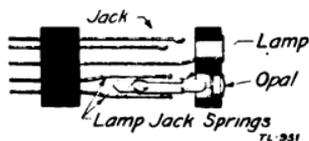


FIGURE 30.—Line jack and associated line lamp.

(c) *Line relays*.—Relays of various types may be associated with line circuits to facilitate auxiliary switching. Use of these relays is indicated in figures 32 and 33.

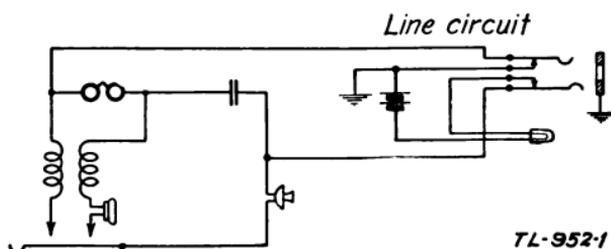


FIGURE 31.—Line circuit with cut-off jack and without line relay.

(2) *Types.*—(a) *With cut-off jack and without line relay.*—Figure 31 illustrates a telephone connected to this type of line circuit. This type of line circuit is found only on small switchboards where the lines are short and of nearly uniform length.

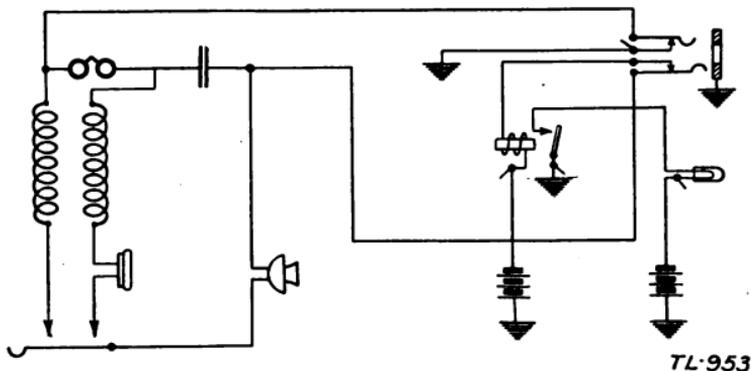


FIGURE 32.—Line circuit with cut-off jack and line relay.

(b) *With cut-off jack and line relay.*—Figure 32 illustrates a booster telephone connected to this type of line circuit. This circuit is found on small switchboards and some larger

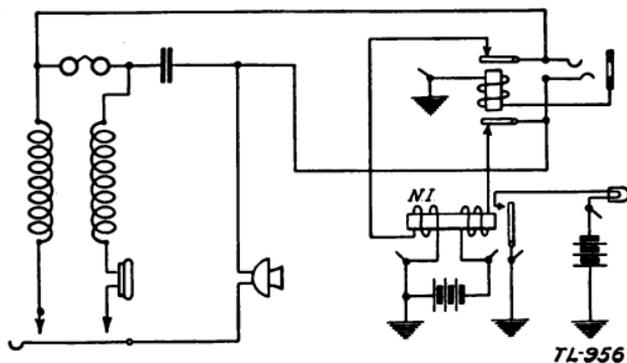


FIGURE 33.—Line circuit with line and cut-off relays.

ones where lines are of unequal length and the traffic load is not so heavy as to make maintenance of contacts and cut-off springs from the front of the switchboard objectionable.

(c) *With line and cut-off relays.*—Figure 33 illustrates a telephone connected to this type of line circuit. This type

of line circuit is found on large switchboards designed for serving the maximum traffic load.

*b. Cord circuits.*—The cord circuits of common battery switchboards are fundamentally the same as those used in local battery switchboards. However, there are many points of difference which are due to the centralization of the battery supply and to the automatic and continuous supervision of the former.

(1) *Cords and plugs.*—(a) *Description.*—Figure 34 shows the plug on a common battery cord circuit inserted in a line jack. The tip, ring, and sleeve contacts on the plug make contact with the corresponding elements of the line jack.

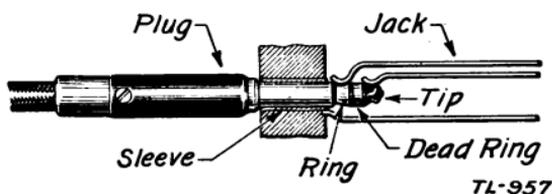


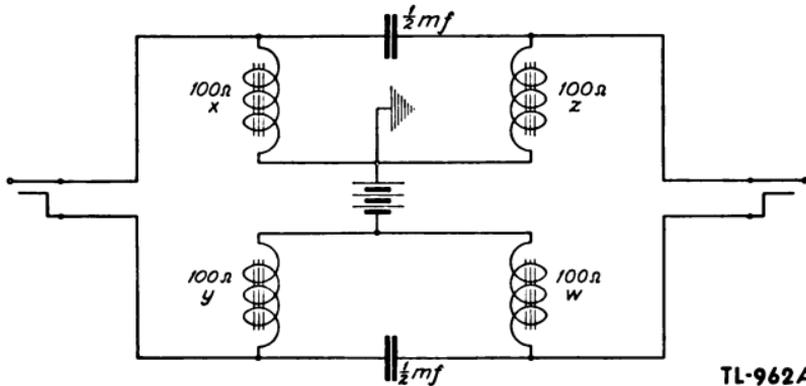
FIGURE 34.—Three-conductor plug in line jack.

(b) *Care and maintenance.*—A frequent source of trouble on cord circuits is the plug and that portion of the cord adjacent thereto. Frayed cords must be cut back and plugs cleaned frequently for best operation. Plugs will be cleaned and polished in accordance with standard commercial procedure. (See par. 159.)

(2) *Battery supply.*—Not only must the central office battery supply power for the operation of central office equipment but also supply, through the cord circuits, power for talking purposes to every common battery telephone on the system. There are two methods for supplying this power through the cord circuits: the retardation coil\* or Stone system and the repeating coil system.

(a) *Retardation coil or Stone system.*—Figure 35 illustrates how battery is supplied to a cord circuit by the retardation coil or Stone system. Each cord circuit has a separate set of coils and capacitors so that the only part of the circuit common to the several cord circuits is the battery itself.

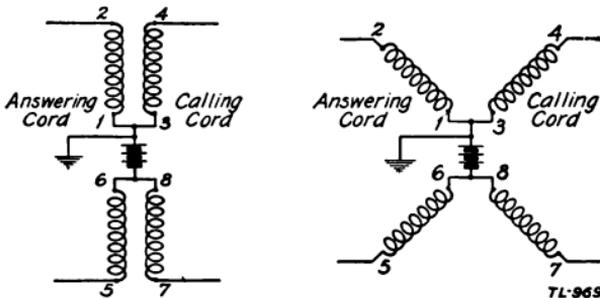
(b) *Repeating coil system.*—In the repeating coil cord system, inductive coupling between the calling and answering



TL-962A

FIGURE 35.—Power supply to retardation coil cord circuit.

sides of the cord circuit is used. Battery is supplied to the cord circuit through the repeating coil as shown in figure 36. This figure also shows the symbolic representation of the connections to a repeating coil for use on a cord circuit.



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FIGURE 36.—Power supply to repeating coil cord circuit.

(3) *Operator's telephone.*—The operator's telephone may be the same as a local battery telephone described in section V, but on switchboards equipped with repeating coil cord circuits it is usually more elaborate in that it uses an anti-sidetone circuit. A diagram of the latter is shown in Figure 37. The resistance of the resistor R is about 370 ohms, the resistance of the average subscriber loop. The network which results when the components, including the subscriber line, are connected, as shown, results in an appreciable reduction in sidetone in the operator's receiver. Considerable sidetone would result if the resistor R were to become open circuited.

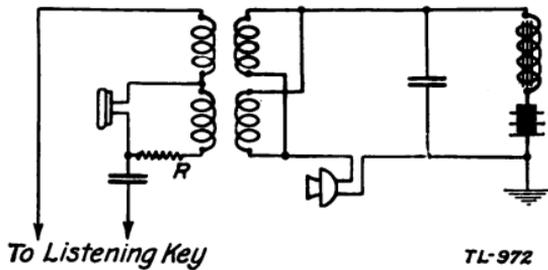


FIGURE 37.—Operator's anti-sidetone telephone.

Connection is made between the operator's telephone and the several cord circuits on the switchboard by means of listening keys, one of which is in each cord circuit. Figure 38 shows the addition of a listening key and an operator's telephone to the retardation coil cord circuit of figure 35.

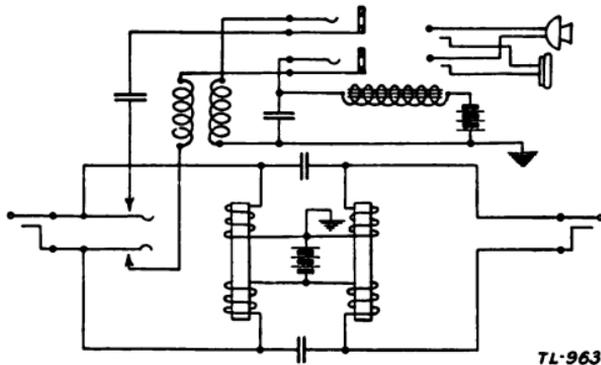
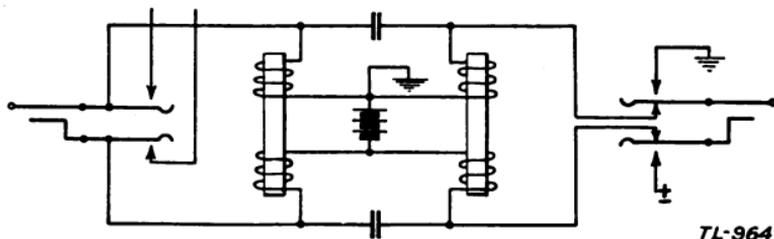


FIGURE 38.—Power supply and operator's telephone on retardation coil cord circuit.

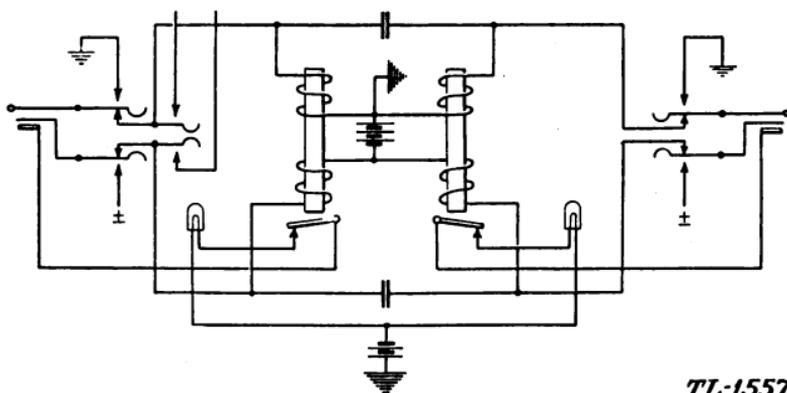
(4) *Signaling circuit.*—By means of ringing keys, one of which is associated with each of the several cord circuits, ringing power is supplied to the calling cord. Operation of the ringing key also opens the cord circuit to the answering cord side of the ringing key. Figure 39 illustrates the manner of connection of a ringing key in the cord circuit of figure 38. A ring-back key is provided on some switchboards. This key allows ringing power to be supplied to the answering cord. The cord circuit of figure 40 shows the connections of such a key.



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FIGURE 39.—Addition of ringing key to retardation coil cord circuit.

(5) *Supervision*—(a) *General*.—Supervision in a common battery switchboard is given by two lamps on the plug shelf, one associated with the answering cord and the other with the calling cord. These lamps are extinguished when the hook switch of the telephone with which they are associated on a connection is up, and they light when the hook switch is depressed.



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FIGURE 40.—Retardation coil cord circuit with open-out supervision.

(b) *Open-out type*.—One method of accomplishing this supervision is illustrated in figure 40. In this type of supervision the sleeve of the line jack is grounded. The cut-off relay type of line circuit cannot be used on switchboards the cord circuits of which use this type of supervisory circuit.

(c) *Shunt-out type*.—Since it is not possible to utilize the magnetic field of the repeating coil in a repeating coil cord circuit to operate armatures, separate supervisory relays are required. The operating windings of these relays must be placed in series with the cord circuit. It is necessary, there-

fore, to furnish a bypass for voice frequency currents. This is accomplished by means of a noninductive winding on the relay. Figure 41 illustrates this type of supervision. This type of supervision may be used with any type of line circuit.

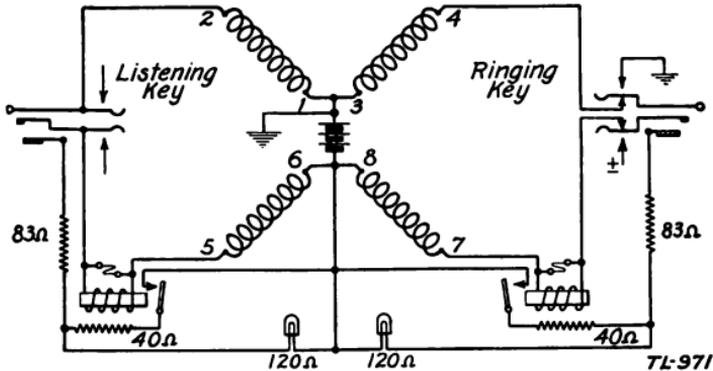


FIGURE 41.—Repeating coil cord circuit with shunt-out supervision.

Also it is possible to use shunt-out supervision with a retardation coil cord circuit and open-out supervision with a repeating coil cord circuit, but this is seldom done.

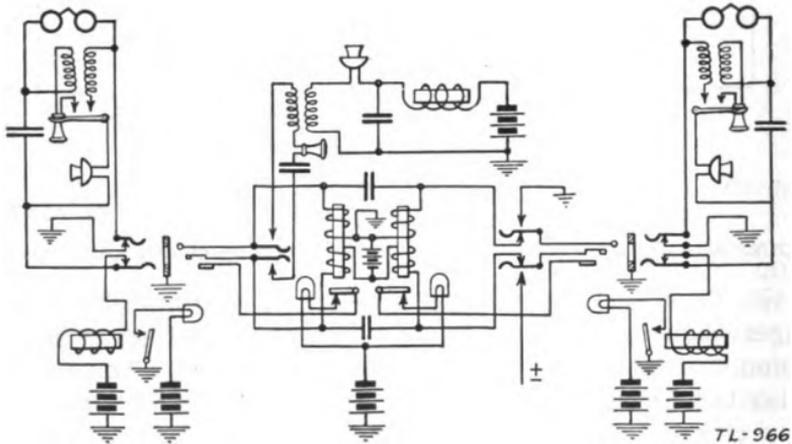


FIGURE 42.—Complete retardation coil cord circuit system.

(6) *Complete circuit.*—Figure 42 illustrates a complete retardation coil cord circuit, two line circuits with cut-off jack and line relay, and two common battery telephones con-

nected to these line circuits. All substation and central office equipment required for signaling, talking, and supervision is shown. Figure 43 shows the same circuits on a switchboard which employs a repeating coil cord circuit and line circuits with cut-off and line relays.

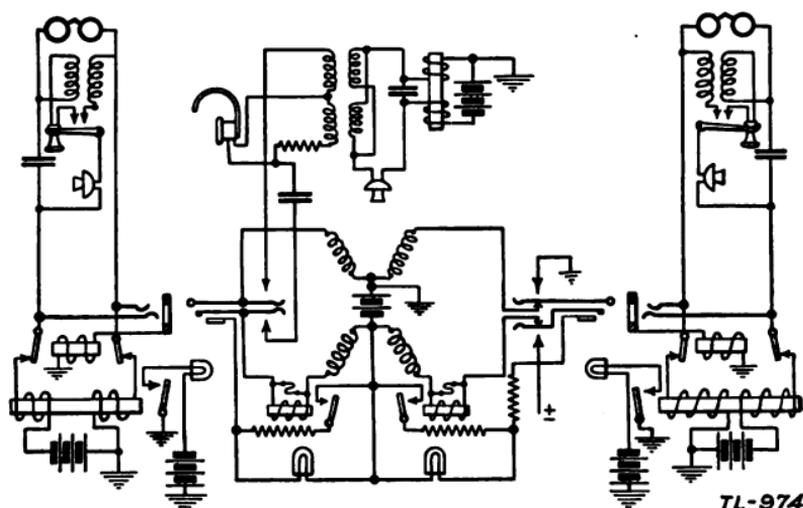


FIGURE 43.—Complete repeating coil cord circuit system

*c. Auxiliary circuits.*—(1) *General.*—In small nonmultiple switchboards the circuits listed below are classed as auxiliary or miscellaneous circuits. The first four are to be found in practically every switchboard, while the others are omitted from some. These auxiliary circuits are not connected with any one line, trunk, or cord circuit, but are the general circuits of the switchboard. They are not essential to the operation, but are in the nature of refinements.

- (a) Line pilot circuit.
- (b) Supervisory pilot circuit.
- (c) Night alarm circuit.
- (d) Generator switching circuit.
- (e) Battery switching circuit.
- (f) Transfer circuit.

(2) *Line pilot circuit.*—A line pilot lamp, prominently placed on the switchboard, is arranged to light every time any line lamp lights. (See fig. 44.)

(3) *Supervisory pilot circuit.*—A supervisory pilot lamp is arranged to light every time any of the several supervisory lamps on the cord circuits is lighted. (See fig. 44.) Cord circuits employing shunt-out type of supervision are not arranged for supervisory pilot circuits.

(4) *Night alarm circuit.*—The flow of current to each pilot lamp is over a common lead which goes to ground through the winding of the night alarm relay. Thus, this relay operates and remains operated as long as either pilot lamp is lighted. A key allows connection of a buzzer or ringer circuit across the contacts of this relay. (See fig. 44.)

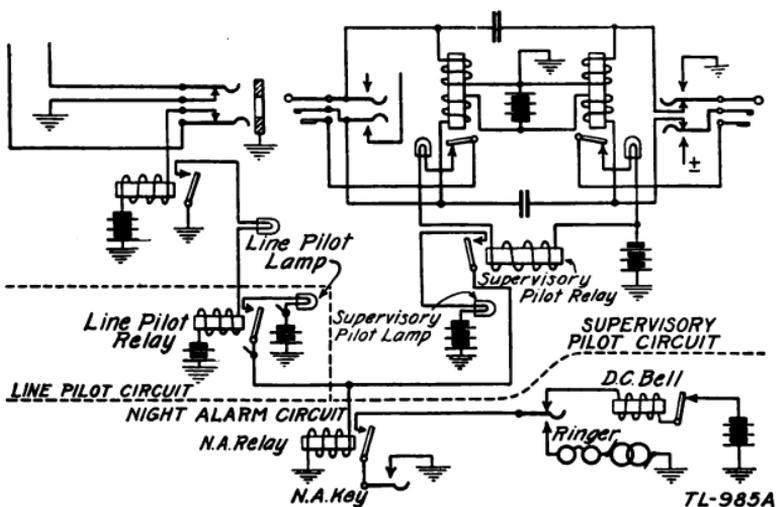


FIGURE 44.—Auxiliary switchboard circuits.

(5) *Generator switching and transfer circuits.*—These circuits are, in general, the same as those of local battery switchboards described in section V.

(6) *Battery switching circuit.*—Not all small switchboards are operated throughout the 24 hours of the day. Commercial PBX switchboards are equipped so that an operator can cut off battery and ground when taking the board out of service. The battery switching circuit, by means of which this operation can be performed, is seldom used on Army switchboards.

*d. Trunk circuits.*—(1) *General.*—There are two-way trunks and one-way trunks. The former are equipped with a signal at each end, while the latter have a signal at the switchboard

on which they appear as an incoming trunk and have only a jack at the switchboard on which they appear as an outgoing trunk. Both classes may be automatic or ring-down, and the two-way trunk may be automatic one way and ring-down the other. An automatic trunk is one which will bring in the signal as soon as the distant operator connects to it; and a ring-down trunk is one which requires ringing current to operate the trunk signal.

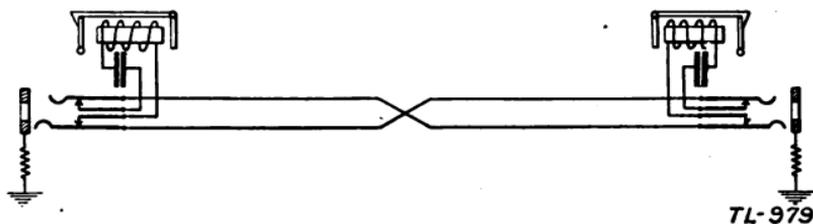


FIGURE 45.—Two-way ring-down trunk with line drops

(2) *Two-way ring-down trunk.*—Figure 45 shows a two-way ring-down trunk with ring-down drops as signals. The capacitors shown are required to avoid false supervision. The two sides of the line are reversed so that the batteries at the two switchboards will be in series and not opposing each other.

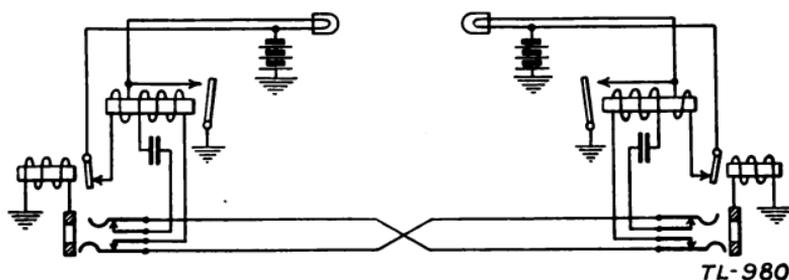


FIGURE 46.—Line lamp on two-way ring-down trunk circuit.

If the batteries were in opposition there would be no supervision on cord circuits used for connection. Figure 46 shows a method of using this trunk with the lamp type of line signal.

(3) *Two-way automatic trunk.*—Figure 47 shows the circuit of a two-way automatic trunk which is often found in use as an interposition trunk at one central office. This cir-

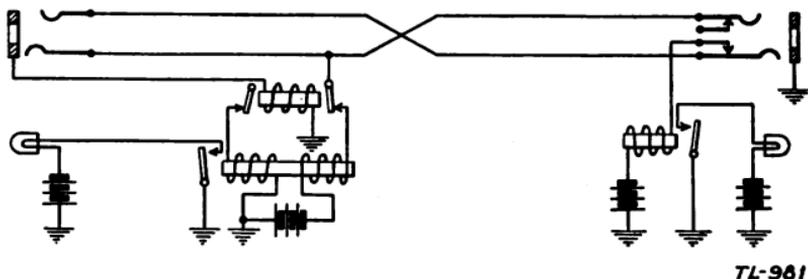


FIGURE 47.—Two-way automatic trunk circuit.

cuit is seldom used on switchboards employing retardation coil cord circuits as improper supervision may result.

(4) *One-way automatic, one-way ring-down trunk.*—Figure 48 shows a trunk circuit which is automatic one-way and ring-down the other. The equipment at the larger exchange is an ordinary line circuit. A repeating coil cord circuit should be used at each end of this trunk.

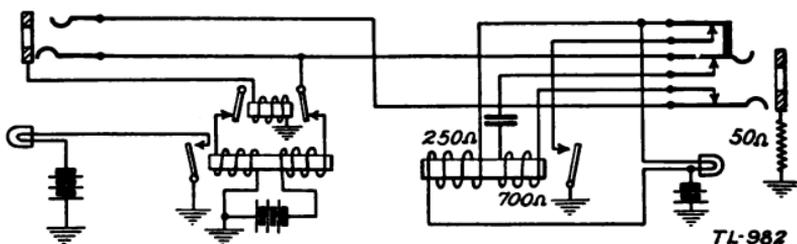


FIGURE 48.—One-way automatic, one-way ring-down trunk circuit.

(5) *Repeating coil trunks.*—Each trunk circuit thus far mentioned requires the proper poling of the circuit for additive connection of the battery, and there is a circuit unbalance if the central office grounds are of unequal potential. To avoid this condition, it is necessary to employ a repeating coil in the trunk circuit. The insertion of a repeating coil will destroy supervision unless some steps are taken to overcome this condition. Figure 49 illustrates a one-way automatic, one-way ring-down trunk circuit which provides for the separation of the central office batteries and at the same time retains supervision. This trunk circuit is typical of one-way automatic, one-way ring-down trunks which are to be found

on practically all small telephone switchboards. It is subject to many variations and extensions, as some trunk circuits are very complex and have six or more relays, each with a definite purpose.

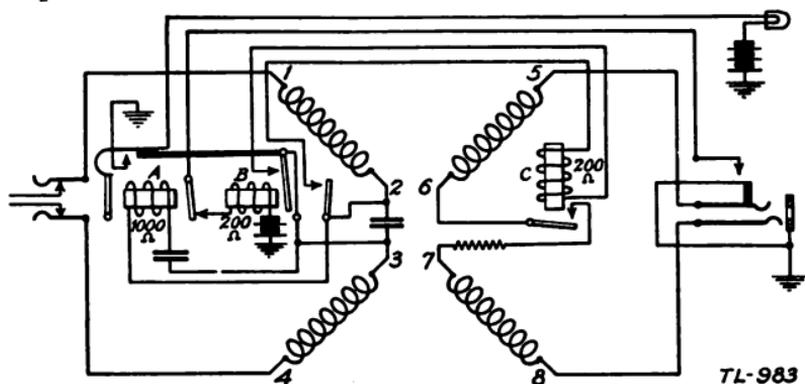


FIGURE 49.—Repeating coil trunk circuit.

■ 151. MULTIPLE SWITCHBOARDS.—*a. General.*—Nonmultiple switchboards, when used in exchanges of more than two positions, require interposition trunks to enable any operator to give connection to lines appearing on the distant positions. When the exchange requires five or more positions, the system of interposition trunks becomes quite complex, and errors in trunking further lower the efficiency of the service rendered. The use of a multiple switchboard is warranted in any exchange requiring four or more positions.

*b. Types.*—(1) *Branch multiple.*—(a) *Circuit.*—If a switchboard line circuit of the cut-off and line relay type is arranged with several line jacks, all of which have their tip, ring, and sleeve contacts connected in multiple, the line signaling equipment will be disconnected by sleeve current when a cord circuit plug is inserted in any one of the jacks. Such an arrangement is known as the branch multiple. Figure 50 illustrates the circuit arrangement of this multiple. An incoming call is signaled by only one line lamp, but on outgoing calls from any position the operator may utilize any one of the several available jacks for completing the call.

(b) *Equalization of traffic load.*—To equalize the traffic load between positions of the multiple switchboard, approximately the same number of line signal lamps are placed at

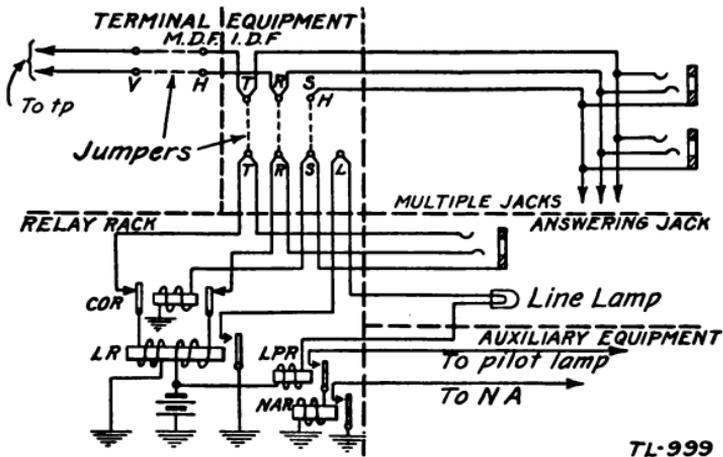


FIGURE 50.—Line circuit, branch multiple.

each position. A heavy load at any one position may be reduced by shifting some of the subscriber lines at the heavy load position to answering jacks at other more lightly loaded positions. The branch multiple system enables any answering jack and associated relay equipment to be connected to any subscriber line by changing a three-wire jumper on the intermediate distributing frame. (See I. D. F., fig. 50.)

(2) *Lamp associated multiple.*—There are multiple installations where each multiple jack has a line lamp associated with it as shown in figure 51. On this multiple there is no separate answering jack, and when any line calls, all lamps on

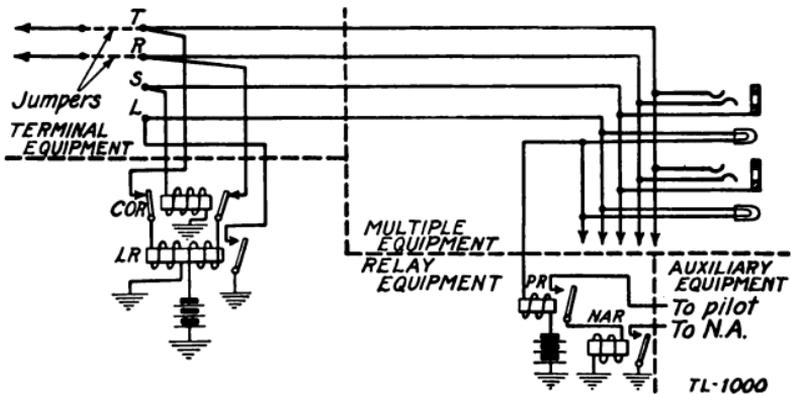


FIGURE 51.—Line circuit, lamp associated multiple.

the multiple light simultaneously. The first available operator plugging into the multiple to answer the call extinguishes all of these lamps. This arrangement effects an automatic distribution of load but reduces the capacity of the switchboard considerably.

*c. Miscellaneous circuits.*—There are several hundred circuits of all types available for any one make and type of multiple switchboard. The number of different circuits required in any switchboard will vary with operating and service conditions. Each installation is covered by a specification, which makes reference to all drawings and wiring diagrams forming a part of it and covering details of the circuits involved.

(1) *Rural lines.*—By a slight modification of a line circuit employing line and cut-off relays, signaling from local battery telephones on lines too long for satisfactory common battery signaling can be accomplished. The modified line circuit is shown in figure 52. Since normal common battery

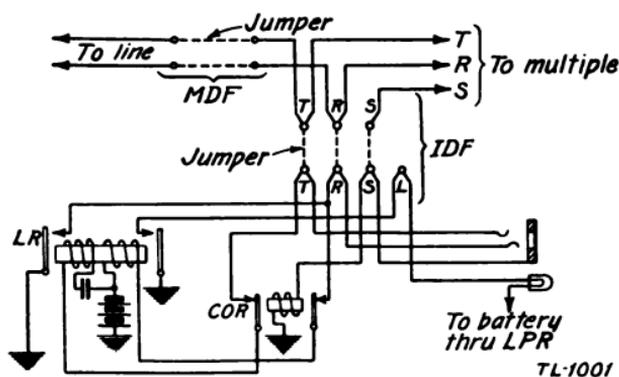


FIGURE 52.—Rural line circuit, branch multiple.

cord circuits are not suited for use with these lines, positions at which these lines terminate are provided with cords similar to those on a local battery switchboard or with universal cords. To distinguish between this line and the normal common battery line, cut-off relays of different resistance are used. The relay on a rural line has a resistance of about 1,000 ohms while the normal relay has a resistance of about 35 ohms.

(2) *Trunks.*—On multiple switchboards all two-way trunk circuits must be provided with multiple jacks and employ relay cut-off. In addition to the two-way trunks covered in paragraph 150, there are toll trunks which carry no direct current and are arranged for connection to subscribers through universal cord circuits. As with rural lines, these trunks have high resistance cut-off relays.

(3) *Cord circuits.*—The subscriber cord circuits of multiple switchboards are usually of the repeating coil type and must have shunt-out supervision or its equivalent. In retardation coil cord circuits for multiple switchboards, it is the practice of some manufacturers to accomplish this by removing supervisory lamps from the sleeve circuit, and to substitute for them marginal relays which operate to control the lamp circuit.

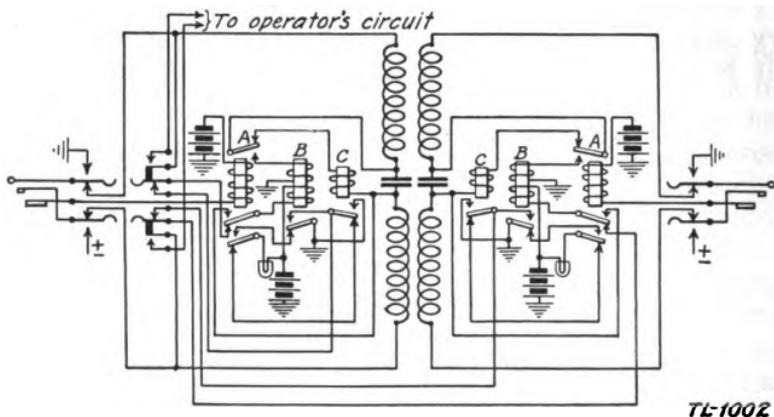


FIGURE 53.—Universal cord circuit.

(4) *Universal cord circuits.*—(a) *Full universal.*—In general these circuits are quite complex. Figure 53 illustrates one arrangement of this type of cord circuit. Since both halves of this cord circuit are the same, either or both of the subscriber's lines may be local battery or common battery.

(b) *Semiuniversal.*—If only one half of the cord circuit is full universal and the other half corresponds to half of a local battery cord circuit, the cord is called a semiuniversal toll cord. It finds employment in completing calls from dry (no d. c. current) toll lines to either dry or wet (d. c. cur-

rent flow) subscriber lines. If one half of the cord circuit is universal and the other half is wet, the cord is called a semiuniversal subscriber cord. This cord is designed to connect common battery subscribers to rural or toll lines. In employing semiuniversal toll or subscriber cords, it is necessary that the operator exercise care to connect the nonuniversal end of the circuit, usually the answering cord, to the proper type of line.

(5) *Other circuits.*—The following list covers some of the other more common circuits, with a brief mention of their purpose:

- | <i>Circuit</i>  | <i>Purpose</i> |
|---|----------------|
| (a) Auxiliary relay—wiring of pilot relays.   |                |
| (b) Auxiliary lamp—wiring of pilot lamps.   |                |
| (c) Fuse alarm—to indicate when certain circuits are open, due to burning out of fuses. |                |
| (d) Night alarm—to connect night alarm into pilot relay circuit.                        |                |
| (e) Transfer key—to group positions.  |                |
| (f) Ringing mains—wiring of power to each position.                                     |                |
| (g) Emergency ringing—wiring of reserve ringing power.                                  |                |
| (h) Peg count—to cut in meters to measure operator's load.                              |                |
| (i) Position clock—to operate clocks on each position.                                  |                |
| (j) Master clock—to synchronize position clocks.  |                |
| (k) Supervisors'—to enable supervisors to check operators.                              |                |
| (l) Monitoring—to enable chief operators and others to check operator's work.           |                |
| (m) Busy back—to put a busy back signal on plug-ended trunks.                           |                |
| (n) Trouble tone—to put a special tone on circuits which are out of order.              |                |
| (o) Howler—wiring of apparatus to generate howler tone.                                 |                |
| (p) Howler cord—to put howler tone on a line to cause restoration of receiver.          |                |

■ 152. CENTRAL OFFICE POWER EQUIPMENT.—*a. Battery.*—(1) *Requirements.*—A 200-line, two-position switchboard can be operated from a 46-ampere-hour battery. If there are more than 175 working lines or an extremely heavy calling rate, a 69-ampere-hour battery is required. Three- or four-position

multiple switchboards (300-400 lines) require 92-ampere-hour batteries, and additional positions require correspondingly larger batteries. For batteries over 250-ampere-hour capacity, a cabinet, with a vent to the outside of the building when practicable, is considered desirable. Eleven cells of battery (not 12) are standard for 24-volt switchboards and 15 cells for so-called 30-volt switchboards.

(2) *Care and use.*—For technical data on the care and use of storage batteries see \*TM 11-430.

(3) *Ground.*—The battery ground of military systems usually consists of a copper plate with a surface of from 20 to 75 square feet, buried to a depth of 6 or 8 feet. The top of the plate should be well below the frost line. The plate should be entirely surrounded by charcoal, and the ground pit should then be filled in with crushed stone or coarse sand. Always place the ground where it will remain damp. If necessary, water the ground. Connect the ground directly to the positive pole of the battery.

*b. Charging equipment.*—(1) *Trickle charge.*—Telephone storage batteries are ordinarily in continuous use, and it is desirable to employ a trickle charge of the batteries while they are in use. This necessitates a uniform and ripple-free charging source, adequate in capacity to provide the charging current plus the normal exchange current load. At locations where a continuous source of a. c. power is available, electron tube rectifiers should be provided as charging equipment.

(2) *Normal charge.*—When duplicate central office batteries are available, one battery may be charged while the other is supplying the load. Charging equipment for a normal charge may be a mercury arc rectifier or a d. c. generator driven by an electrical motor. The type of motor required is determined by the type of electrical power available at the central office. A gasoline engine driven d. c. generator should always be available as an emergency source of charging power.

■ 153. RINGING MACHINES.—*a. General.*—Ringing machines used at central offices are either vibrating or rotary machines. Vibrating machines are used in local battery and in small common battery centrals. Rotary machines found in larger common battery centrals are rotary pole changers, ringing

\*See Appendix.

dynamotors, or ringing generators. Two ringing machines should be provided for all common battery centrals. They may be either vibrating or rotary depending upon requirements, but the larger centrals generally use rotary machines. Most rotary machines are designed to operate from commercial power, but emergency dynamotors are designed to operate from the central battery.

b. *Vibrating machines.*—(1) *Vibrating pole changer.*—Figure 54 shows the circuit of a simple type of vibrating pole changer. The driving battery may be a storage battery or dry cells. The ringing battery is commonly composed of 72 dry cells.

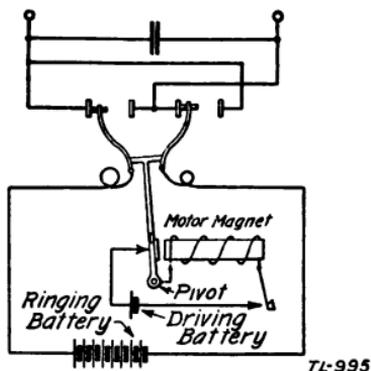


FIGURE 54.—Vibrating pole changer.

(2) *Telering.*—The telering is a vibrating machine by which ordinary 60-cycle single-phase power supply is converted into a 20-cycle single-phase ringing current. Figure 55 shows the circuit of this machine. It is not suitable for heavy ringing loads but serves adequately boards up to 300 lines.

c. *Rotary machines.*—(1) *Rotary pole changer.*—The ringing machine (fig. 56) is quite suitable for use in medium-sized centrals and for a reserve machine in larger centrals.

(2) *Ringing dynamotors.*—Ringing dynamotors consist of a double wound armature rotating in a single field. The field and one of the armature windings are usually energized by the 24-volt central battery. The second winding develops

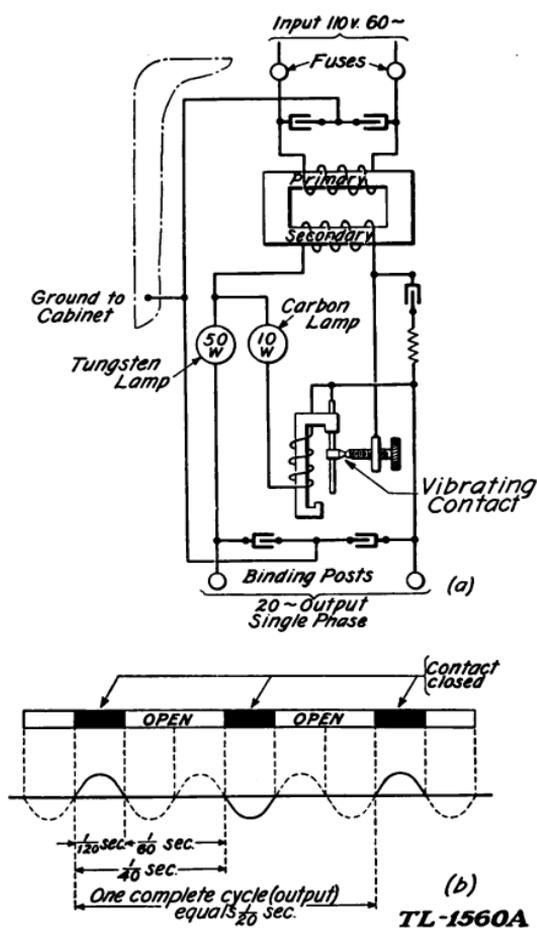


FIGURE 55.—Telering circuit.

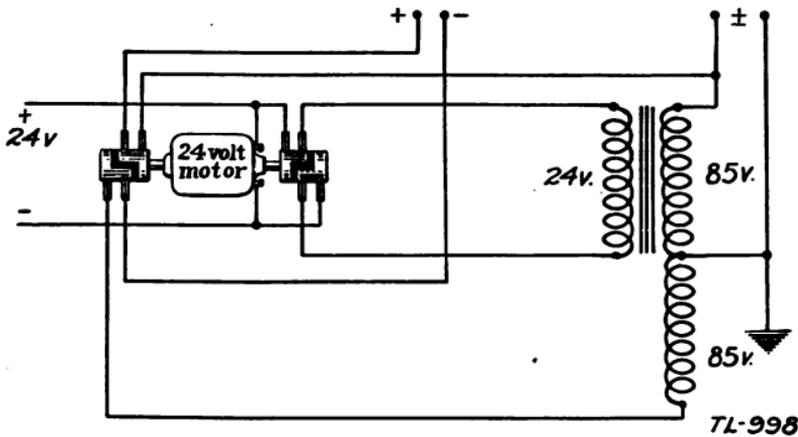


FIGURE 56.—Rotary pole changer.

75 to 85 volts at 16-20 cycles. These machines are available in different sizes and are often used as reserve machines.

(3) *Ringng generators.*—For large centrals, ringing generators are ordinarily used. They may be directly connected to the driving motor forming a motor generator, or may be belt driven by a motor for a main ringing source or by a gasoline engine for a reserve machine. The same ringing generator may deliver alternating voltage at a frequency of 20 cycles per second, alternating voltage at several different tone frequencies, and pulsating d. c. voltage at 20 cycles per second.

■ 154. SELECTIVE RINGING.—*a. General.*—It often is necessary to connect two telephones to the same line. By means of selective ringing it is possible to signal one of these without disturbing the other. However, there is nothing to prevent either of the subscribers from listening to conversations of the other. A subscriber can call or be called only when the line is not in use by the other party on the line.

*b. Ringng to ground.*—Figure 57 illustrates the arrangement of two telephones on a single line and the ringing connections at the central office to effect selective ringing.

*c. Other methods.*—In addition to the system shown in *b* above, selective ringing of several telephones on the same line may be accomplished by pulsating ringing or harmonic ring-

ing. Although these systems are feasible for use on an Army exchange, they are installed only as a temporary expedient. By placing only unimportant and little used telephones on party lines, code ringing (a series of short or long rings) and ringing to ground will usually prove adequate.

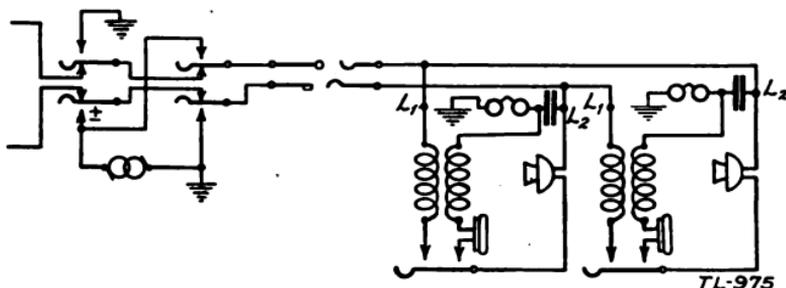


FIGURE 57.—Two-party selective ringing.

■ 155. DISTRIBUTING FRAMES.—*a. General.*—Central office distributing frames may be either main frames, intermediate frames, or a combination of both. All telephone centrals make use of the main frame or its equivalent, while the intermediate frame is used only in multiple centrals. In small multiple centrals the main frame and intermediate frame are often combined.

*b. Improvised frame for small switchboards.*—An improvised distributing frame is used with the switchboard BD-14. This improvised frame may be constructed from 2- by 4-inch lumber with vertical supports, cross arms, and cross members. Terminal strips and insulators are attached so that the frame may, while affording the cross-connecting facilities of a distributing frame, also serve to keep circuits overhead around the telephone central. Portability and ease of installation govern the details of design. This frame may be so constructed that it can be used as the front support of the tent or be attached to the body of the truck used to house the telephone central. By constructing the vertical supports in two sections, the improvised frame may be designed to facilitate its use either with the tent or truck.

*c. Main frames.*—Main distributing frames may be wall type or floor type. Wall-type frames are generally used in centrals with less than 200 lines, and floor-type frames are

used in all others. Protectors are mounted on one side of the frame and terminal blocks on the other. The outside circuits terminate on the protector side of the frame, and the switchboard circuits terminate on the terminal blocks. The circuits are cross connected with two-conductor jumper wire. (See fig. 50.) The circuits are carried from the terminal side of the main frame to the switchboard (or to the horizontal side of the intermediate frame when a separate intermediate frame is used) in switchboard cable run on cable racks. When an intermediate distributing frame is used, the multiple circuits are cabled to the horizontal side and the answering jack circuits to the vertical side. The circuits are then cross connected with three-conductor jumper wire. (See fig. 50.)

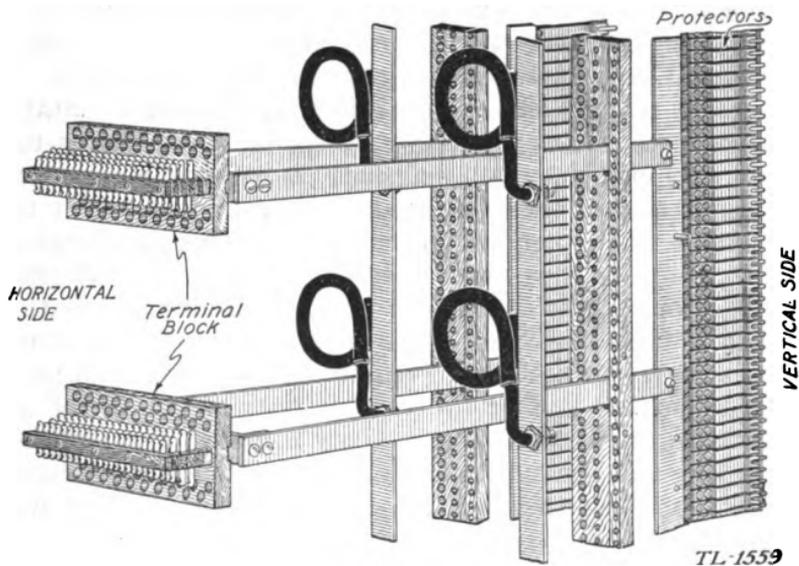


FIGURE 58.—Section of a main distributing frame

*d. Intermediate frames.*—Intermediate distributing frames, used in multiple offices, provide a means for equalizing the load on the several positions of the multiple switchboard. The construction of this frame is very similar to that of the main frame, the essential differences between these two frames being listed below.

(1) The main frame contains the protectors in addition to the terminals while the intermediate frame has only terminals.

(2) Two-conductor jumpers connect the vertical side of the main frame to the horizontal side, whereas there are three-conductor jumpers between sides of the intermediate frame.

■ 156. CABLE RACKS.—Iron cable racks are frequently required for supporting the switchboard cables between the switchboard and the distributing frames. These cables, usually 20-pair switchboard cable, are laced to the racks with the lock stitch. (See FM 24-5.)

■ 157. CENTRAL OFFICE TESTING.—*a. General.*—All testing equipment, with the exception of linesmen's and cable splicers' portable test sets, is located at the central office. The central office personnel is charged with all testing. A wire chief's test set varies from the simple cabinet containing a voltmeter and a number of switching keys to large test boards equipped with all necessary apparatus for making any test or measurement desired. The principal use of the wire chief's test set or test board is for testing and locating outside trouble. It is never used for locating central office trouble, though it is often used for determining the nature of central office line and trunk trouble. The efficient use of the wire chief's test board requires a thorough knowledge of the apparatus and of the various tests of which the set is capable. Since there are so many different types of test boards, any one of which is likely to be installed in a military telephone system, this manual describes in a general way only a few of the more commonly used tests.

*b. Murray and Varley loops.*—The Murray and Varley loops are modifications of the Wheatstone bridge. They are used for determining the exact resistance of a wire between the test point and the fault. Then by dividing this resistance by the resistance per unit length of the particular wire under test, the exact location of the fault is determined. When testing apparatus is provided which is capable of being used for making Murray and Varley loop measurements, a set of

operating instructions for the use of such apparatus should also be furnished.

*c. Voltmeter tests.*—Voltmeter tests are completely covered in FM 24-5.

*d. Relay tests.*—(1) All common battery centrals should be provided with relay testing apparatus. This may be a very simple resistance box, equipped with keys for completing a circuit through the relay and a resistor of any desired resistance value. It may also be a current flow test set, arranged for varying current through the relay between fixed limits. Generally a resistance box relay test set is arranged to test circuits through 1,000 ohms, 750 ohms, and a dead short. There is a 10,000-ohm resistance bridged across the circuit at all times. Maintenance rules generally require that cord and line relays be adjusted to operate freely on 750 ohms and release quickly after having been saturated for 2 or 3 seconds with current caused by a dead short. Relays of long-line circuits are sometimes adjusted to operate on 1,000 ohms. The set is not used for testing other relays.

(2) The current flow test set may be used for testing any type of telephone relay. A set of operating instructions should be furnished with the set.

■ 158. CENTRAL OFFICE TROUBLES.—*a. Indication and probable cause.*—The following list shows the indication and probable cause of a number of the more common types of common battery central office troubles. The assumption is made that in each case the trouble is confined to the central office.

(1) *Line circuit.*

*Indications of trouble*

*Probable cause*

(a) Permanent signal.

(a) Heat coil blown. Dirty carbons. Ring grounded at protector or at jack. Shorted at protector, on distributing frame, or at multiple or answering jack.

(b) Cannot signal operator.

(b) Relay not operating or dirty contacts. Open lamp. Open circuit at frame or at answering jack.

*Indications of trouble*

(c) Can signal operator but cannot talk.

(d) Cannot plug out signal.

(e) Can hear cross talk.

(f) Gives false busy test.

*(2) Cord circuit.**Indications of trouble*

(a) Can talk but cannot ring.

(b) Can ring but cannot talk.

(c) Supervisory lamp burns while talking.

(d) Supervisory lamp does not light when subscriber hangs up.

(e) Supervisory lamp does not light at any time.

(f) Cross talk.

(g) Noisy.

*Probable trouble*

(c) Tip or ring open at jack.

(d) Sleeve open at jack, distributing frame, or at cut-off relay. Cut-off relay out of adjustment or open. Line relay sticks. Jack sleeve grounded.

(e) Tip or ring crossed with another circuit at protector, distributing frame, or at jack. Damp switchboard cable.

(f) Sleeve crossed at jack or at distributing frame.

*Probable cause*

(a) Ringing key contact not making. Open ringing strap.

(b) Listening key contact not making. Open listening strap.

(c) Relay out of adjustment. Shunt resistance open or open at resistance or at relay contacts.

(d) Relay out of adjustment.

(e) Open lamp. Relay stuck. Open sleeve at resistance, at lamp, or at fuse.

(f) Crossed with another cord circuit at cord shelf or at repeating coil.

(g) Worn cord. Dirty plug. Loose contact at key, relay, or repeating coil.

*Indications of trouble*

- (h) Gives false busy test.
- (i) Can ring on keys 1 to 5 only.
- (j) Cannot ring on position.

(k) Cut-off while talking.

**(3) Operator's telephone circuit.***Indications of trouble*

- (a) Can hear but cannot talk.

(b) Can be heard but cannot hear.

(c) Noisy.

**(4) Pilot and night alarm circuits.***Indications of trouble*

(a) Pilot lamp does not light.

(b) Pilot lamp burns continuously.

(c) Night alarm bell does not operate.

*Probable cause*

(h) Dead ring worn.  
(i) Open ringing strap between keys 5 and 6.

(j) Open generator lead at ringing key. Open ringing resistance or open at resistance.

(k) Loose contact or loose connection in key, in cord, at cord shelf, or at repeating coil.

*Probable cause*

(a) Transmitter cord open in operator's set or defective transmitter. Open at operator's jack, at induction coil, or at retardation coil. Defective induction coil, retard coil, or open fuse.

(b) Defective receiver or open in receiver circuit.

(c) Worn cords. Dirty plug. Loose contact in transmitter circuit.

*Probable cause*

(a) Pilot relay out of adjustment. Pilot lamp open or open connection at lamp, at pilot relay, or at night alarm relay.

(b) Pilot relay stuck.

(c) Night alarm relay out of adjustment. Open at night alarm key or at relay contacts.

*Indications of trouble*

(d) Night alarm bell rings continuously.

*Probable cause*

(d) Night alarm relay stuck. Night alarm lead to relay grounded.

*b. Locating central office trouble.*—The simple head receiver is the instrument most often used for locating trouble on central office circuits. It is equipped with cords or feelers for bridging between ground and battery. A complete circuit manifests itself by producing a click in the receiver. If the circuit is completed through a condenser there will be a click when the circuit is first made, but upon removing the connection and making it again there will be no click. So by making and breaking the connection two or more times it is easy to differentiate between a complete metallic circuit and a complete circuit containing a condenser. The use of the receiver for testing can best be explained by an example. Take for instance a telephone cord circuit of the shunt type and assume that the supervisory lamp of the answering cord is burned out. (See fig. 43.) The operator will report it as not giving supervision. The maintenance man knows that there should be negative battery on the sleeve of the plug, and that the path of the current is from the battery through the fuse, the lamp, the 83-ohm resistance, and the sleeve conductor of the cord to the sleeve of the plug. He touches one lead of his receiver to ground and the other to the sleeve of the answering plug, and hearing no click in his receiver he knows that the circuit is open between the sleeve of the plug and battery. He next makes the same test at the cord shelf with the same result. He then applies the test at the 83-ohm resistance and at one lamp terminal without result. But when he makes the test at the other lamp terminal, a complete circuit is indicated by a click in his receiver which shows that the trouble is in the lamp. By similar tests a maintenance man can quickly localize any case of central office trouble, provided of course that he understands the operation of the circuit.

■ 159. STANDARD COMMERCIAL PRACTICES.—The installation and maintenance of common battery telephone systems will conform with standard commercial practices. Sets of suitable specifications covering commercial installation and maintenance are issued to units concerned.

## SECTION VII

## TELEGRAPH SYSTEMS AND EQUIPMENT

■ 160. PURPOSE.—The purpose of this section is to cover briefly the technical features of standard wire telegraph systems and equipment employed in the theater of operations which are not completely covered in other War Department publications.

■ 161. SYSTEMS IN GENERAL.—*a. Types.*—There are two types of telegraph systems: the *open-circuit* system and the *closed-circuit* system.

*b. Line circuits.*—The wire line employed on each system is the same. In field wire systems the telegraph line circuit is obtained by simplexing telephone circuits. On lines of a more permanent character the need for more telegraph channels than can be obtained by simplexing existing telephone circuits may indicate the advisability of compositing existing telephone circuits.

(1) *Simplex circuit.*—A complete description of this circuit is given in FM 24-5.

(2) *Composite circuit.*—Necessary equipment and the manner of its connection in order to composite an existing telephone circuit to furnish, in addition, two telegraph channels are indicated in figure 59. Ordinary low frequency ringing current, if used on a composite circuit, would pass through

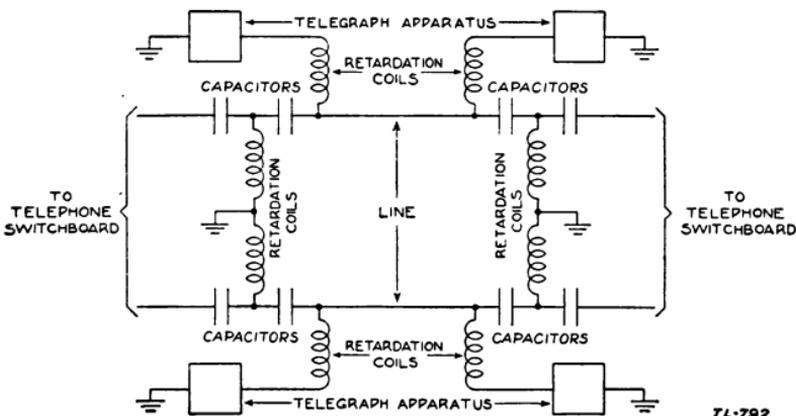


FIGURE 59.—Composite circuit.

the retardation coils and interfere with the operation of the telegraph apparatus. A composite ringer, designed to operate on 133 cycles, is therefore required at the telephone central. The composite ringer (not to be confused with a ringing machine or a ringer in a telephone) is both cumbersome and delicate and is best adapted to permanent installations. For these reasons composite circuits will rarely be used except where telephone centrals are more or less permanently located. Either a side circuit or a phantom circuit may be composited. However, if one side circuit of a phantom group is composited, both must be so treated in order to avoid unbalancing the phantom.

*c. Operation.*—Messages are transmitted over each system by alternately pressing and releasing a telegraph key, and are received by hearing the sound made by the sounder or other sound-producing object. The operation of telegraph printers is described in paragraph 175.

*d. Channels.*—Paragraphs 162 to 175 describe single-line telegraphy, and paragraphs 176 to 181 describe multichannel telegraphy.

■ 162. EQUIPMENT IN GENERAL.—Except for that listed in *a* and *b* below, standard commercial equipment is used almost entirely. This equipment includes keys or other transmitting equipment, batteries or other sources of electrical power, sounders or other receiving equipment, relays, switchboards, repeaters, and other equipment, the most important of which is briefly described in subsequent paragraphs.

*a. Standard.*—The following standard military equipment is completely covered in the publications indicated:

- (1) Telegraph set TG-5—\*TM 11-350.
- (2) Telegraph set TG-5-A—\*TM 11-351.

*b. Limited standard.*—The following limited standard military equipment may remain in use for some time and is covered in the publications indicated:

- (1) Buzzerphone EE-1-A—\*TM 11-352.
- (2) Telegraph set EE-76—Signal Corps General Catalog.

■ 163. OPEN-CIRCUIT SYSTEM.—Figure 60 shows schematically the arrangement of a typical open-circuit system of

\*See Appendix.

three stations, A, B, and C. The following features of this system are noteworthy:

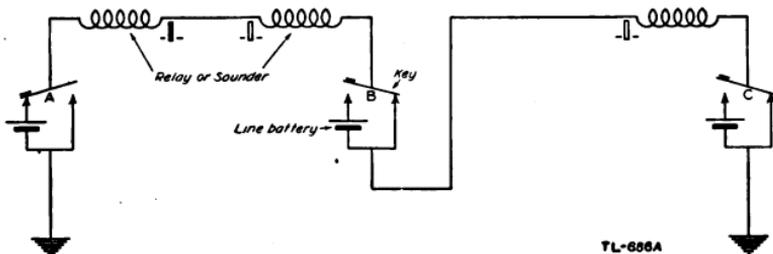


FIGURE 60.—Open-circuit telegraph system.

a. The two terminal stations A and C are grounded while the intermediate or way station B is not.

b. Each station has a line battery which is connected to the line when the key at that station is depressed as at station A, and disconnected from the line when the key at that station is released as at stations B and C. Consequently, when the keys at all stations are released, there is no flow of current in the system with no drain on any of the line batteries, but when the key at one station is depressed, the line battery at that station alone is connected to the line, and the battery must have sufficient voltage to operate all of the receiving equipment at all stations in the system.

c. The key at each station has two contacts. The front contact performs the function in b above, and when the key is released the rear contact completes the circuit at that station.

■ 164. CLOSED-CIRCUIT SYSTEM.—Figure 61 shows schematically the arrangement of a typical closed-circuit system of three stations, A, B, and C. The following features of this system are noteworthy:

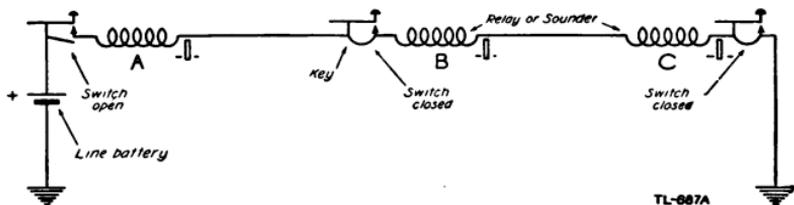


FIGURE 61.—Closed-circuit telegraph system.

a. As in the open-circuit system, the two terminal stations A and C are grounded while the intermediate or way station B is not.

b. There is only one line battery in the system. This battery may be located at one central point as shown in figure 61 or it may be divided into smaller batteries and distributed along the line. Usually a single battery is located at a convenient place to furnish power for a number of systems such as that shown in the figure. When no station is operating and the key switches are closed at all stations, there is a constant flow of current in the system and the battery furnishes power continuously.

c. The key at each station has only one contact but has a circuit-closing switch not possessed by an open-circuit key. When this switch is closed as at B and C, the circuit is completed at those stations and the keys thereat cannot be used for transmitting, but when the switch is open as at A, the contact on the key at that station closes and opens the circuit as the key is depressed or released, respectively.

■ 165. COMPARISON OF SYSTEMS.—a. The closed-circuit system requires fewer line batteries. Its one battery may be divided between the two terminal stations or otherwise distributed, but the total voltage used remains the same as though it were concentrated. In the open-circuit system each station, including each way station, must have sufficient line battery to operate the entire system, and this is undesirable if there are many stations in the system.

b. The open-circuit system uses less power because current flows in it only during transmission, while in the closed-circuit system the flow of current is continuous except when the circuit is broken by the key or its switch. This difference is not great if the system is operated continuously and if storage or gravity batteries, which operate better with fairly continuous use, can be employed. When such batteries can be used, the cost of power is very small compared with the greater cost of open-circuit equipment. When, however, dry batteries must be used, and the system remains idle much of the time, as do field systems of lower units, the open-circuit system reduces the consumption of dry batteries.

c. The open-circuit system operates better over leaky lines such as may be expected in the systems of lower units.

d. Because of the above considerations, systems forward of division headquarters are usually open-circuit systems, and those in rear thereof are closed-circuit systems. Telegraph sets TG-5, TG-5-A, and buzzerphone EE-1-A operate on open-circuit systems only, but telegraph printers operate on closed-circuit systems only.

■ 166. Keys.—The keys mentioned below are typical examples of many available types.

a. *Open circuit.*—Figure 62 shows an open-circuit key.

(1) *Connections.*—To use this key, connect the rear (lever) binding post to the line, the front binding post to one ter-

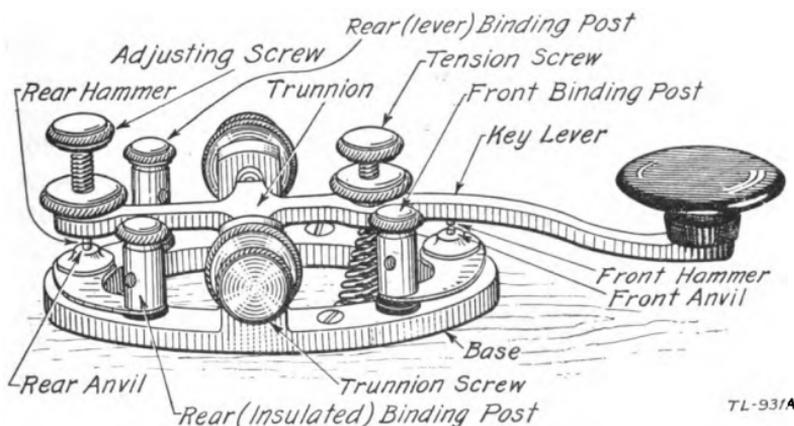


FIGURE 62.—Open-circuit telegraph key.

terminal of the line battery, and the rear (insulated) binding post to the ground and to the other terminal of the line battery.

(2) *Adjustment.*—To adjust the key—

(a) Disconnect one terminal of the battery from the key so that if both contacts are closed during adjustment, the battery will not be ruined or the expensive contacts of the key will not be damaged by excessive current.

(b) See that the hammers are directly over the anvils. If not, loosen the lock nuts on the trunnion screws, and turn these screws until the hammers are in the proper positions

and the lever works freely without undue play. Tighten the lock nuts.

(c) Loosen the lock nut on the adjusting screw, and turn this screw until the distance between the front hammer and anvil is about 0.008 inch (about the thickness of three sheets of bond paper) with the front of the key lever raised. Tighten the lock nut.

(d) Loosen the lock nut on the tension screw, and turn this screw until the front contact can be made easily by the hand and will be broken sharply by the spring. Tighten the lock nut.

b. *Closed circuit.*—(1) Figure 63 shows an ordinary closed-

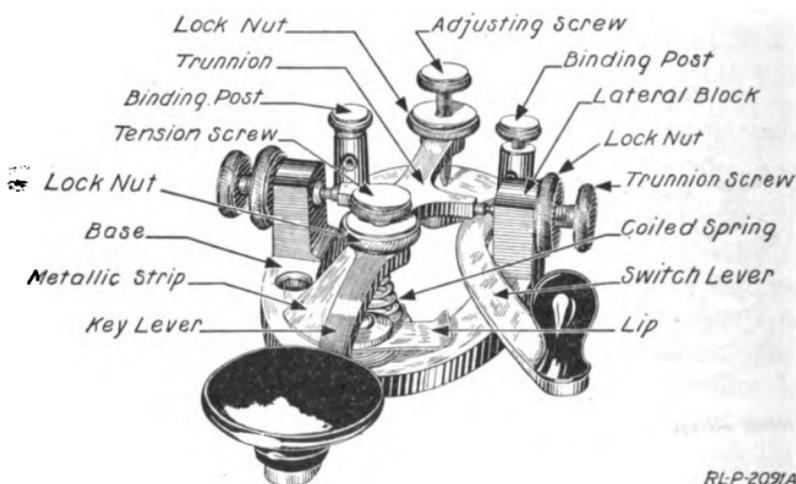


FIGURE 63.—Closed-circuit telegraph key.

circuit key. To connect this key, connect it in series with the line as shown in figure 61 and adjust it as in *a* (2) above.

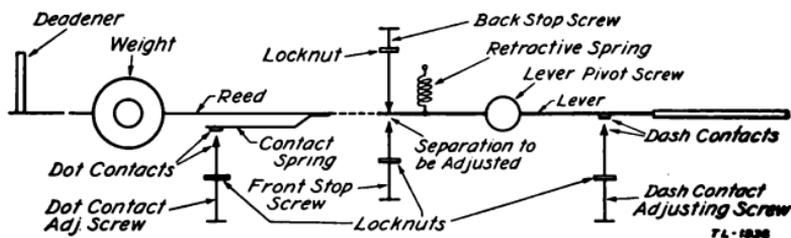


FIGURE 64.—Schematic diagram of key J-36.

(2) Figure 64 is a schematic diagram showing the principal parts of the key J-36, which is a high speed, vibrating type of closed-circuit key commonly known as a "bug."

(a) *Connection.*—To use the key, connect it as any other closed-circuit key or insert its plug in the lip of the key shown in figure 63 if such a key is already connected.

(b) *Adjustment.*—To adjust the key, place it on a level surface. Loosen the lock nut on the back stop screw, turn this screw until the reed lightly touches the deadener, and tighten the lock nut. Loosen the lock nut on the front stop screw, turn this screw until the distance between the end of this screw and the lever is about 0.015 inch (about the thickness of five sheets of bond paper), and tighten the lock nut. Adjust the dash contacts similarly. Operate the lever to the right, hold it in this position, and stop the vibration of the reed; loosen the lock nut on the dot contact adjusting screw, turn this screw until the dot contacts just make without flexing the contact spring, and tighten the lock nut. As this is a very important adjustment, check it after tightening the lock nut. Keep the weight for regulating the speed of dots well toward the outer end of the reed. If the dots are either too light or too heavy, correct this condition by adjusting the position of the weight on the reed. After adjustment, do not change adjustments to correct light or heavy signals except by moving this weight. If the key is equipped with two weights, always keep one weight near the outer end of the reed.

■ 167. **SOUNDERS.**—*a. General.*—A sounder is used to make telegraph signals audible. Figure 65 shows a common type of local sounder. The main-line sounder is not illustrated but its principal mechanical difference from the local sounder is that it has an adjustment for changing the distance between the magnets and the armature which is not found in the local sounder.

*b. Description.*—The windings of the coils are in series with the two binding posts, and when a current flows through the coils, the armature pulls the lower stop on the sounding bar against the frame, causing a click which is magnified somewhat by the sounding board effect of the metallic base. When the current is interrupted, the sounding bar is forced upward

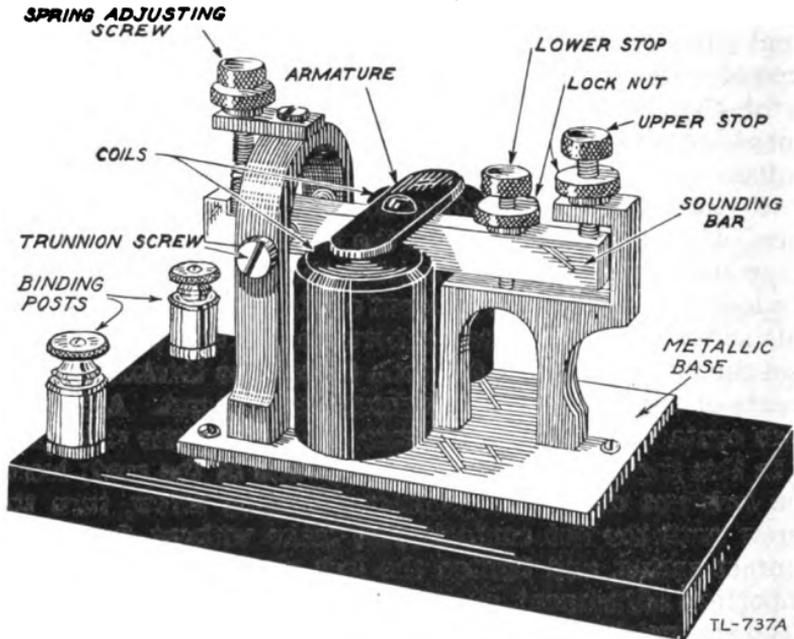


FIGURE 65.—Telegraph sounder.

and against the upper stop by the spring at the other end of the sounding bar, causing a slightly different click.

*c. Adjustment.*—To adjust the sounder—

(1) Loosen the lock nut on the lower stop, turn this stop so that when the sounding bar is held down, the distance between the armature and the tops of the magnets in the coils is about the thickness of two or three sheets of bond paper, and tighten the lock nut. If the armature actually touches the magnets, it will stick.

(2) Loosen the lock nut on the upper stop, turn this stop so that when the sounding bar is held down, the distance between this stop and the sounding bar is about the thickness of a thin dime, and tighten the lock nut.

(3) Adjust the trunnion screws so that the sounding bar will work freely but without undue play at the trunnions.

(4) Loosen the lock nut on the spring adjusting screw, turn this screw so that with normal operating current the sounding bar is drawn sharply against the frame, and with no current it is forced sharply against the upper stop.

■ 168. USE OF SOUNDERS AND RELAYS.—*a. Electrical characteristics.*—The most commonly used relays and sounders have the following electrical characteristics:

Equipment	Resistance in ohms	Normal operating current in milliamperes
Relay.....	{ 75 150 250	{ 80 40 25
Local sounder.....	{ 4 20	{ 250 175
Main-line sounder.....	150	40

*b. Use.*—(1) *Local sounder alone.*—Only in the most unusual case would a local sounder alone be used in the systems shown in figures 60 and 61. To make readable signals, the sounder must give sharp, distinct clicks, and the large operating current of this sounder would cause a waste of energy in any system.

(2) *Main-line sounder alone.*—Although a main-line sounder alone is often used in the systems shown in figures 60 and 61, a sounder operates most satisfactorily when the operating current remains constant, and the current in a telegraph line varies widely due to various conditions, chief of which is the weather.

(3) *Relay and local sounder.*—In most systems a relay and a local sounder are used as indicated in figure 66. Of those shown in *a* above, the 150-ohm relay and the 20-ohm local sounder are most commonly used in systems not employing standard telegraph sets or telegraph printers.

■ 169. RELAY.—*a. General.*—A relay is used in the main-line circuit for purposes of receiving the signals and relaying

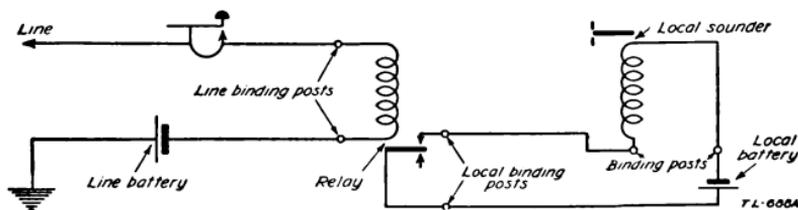


FIGURE 66.—Relay and local sounder.

them to local apparatus which makes them audible. Feeble main-line currents will operate it. Figure 67 shows a relay.

*b. Description.*—The windings of the coils are in series with the line binding posts, and when a current flows through the coils the armature is pulled toward the coils, closes the front contact, and thus closes the circuit between the local binding posts. When the current is interrupted, the armature is pulled away from the coils and breaks the circuit between the local binding posts.

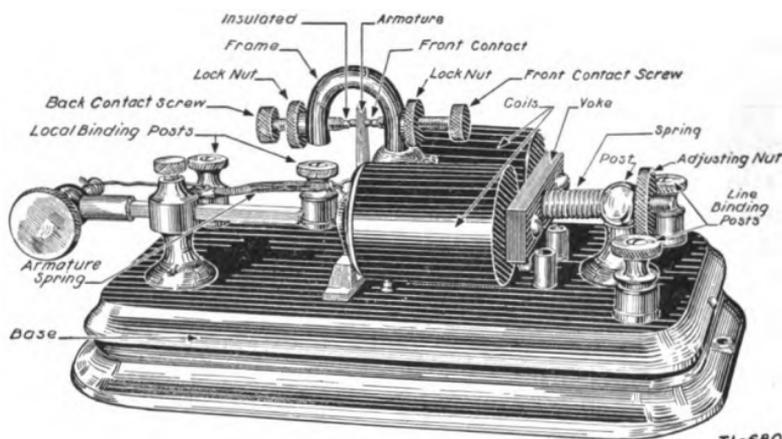


FIGURE 67.—Relay.

*c. Adjustment.*—To adjust the relay—

(1) Loosen the lock nut on the front contact screw, turn this screw so that the armature stands vertically when the contact on the armature touches the screw, and tighten the lock nut.

(2) Loosen the lock nut on the back contact screw, turn this screw until the gap between it and the contact on the armature is about 0.006 inch (about the thickness of two sheets of bond paper), and tighten the lock nut.

(3) Adjust the tension on the armature spring so that it will draw the armature away quickly from the front contact screw when the line circuit is opened but will not unduly strain the spring.

(4) Request a distant station to transmit and turn the adjusting nut which varies the air gap between the cores

of the coils and the armature so that the armature strikes the two contact screws with equal force.

■ 170. SWITCHBOARDS BD-50 AND BD-51.—Switchboards BD-50 and BD-51 are peg-type switchboards of four and eight line capacity, respectively, used at way stations for switching and testing telegraph circuits. Switchboard BD-50 is shown in figures 68 and 69. Switchboard BD-51 is similar but about twice as large. Each of the line binding posts at the top is connected to a vertical strip. Each horizontal row of disks is connected to the corresponding binding post on the side. Line circuit wires are connected to the line binding posts, and the ground and the operating equipment are connected to the binding posts on the side. Connections between strips and disks are made by plugging brass pegs into the openings between the strips and disks. Various combinations of line circuits and local circuits may be obtained with these switchboards.

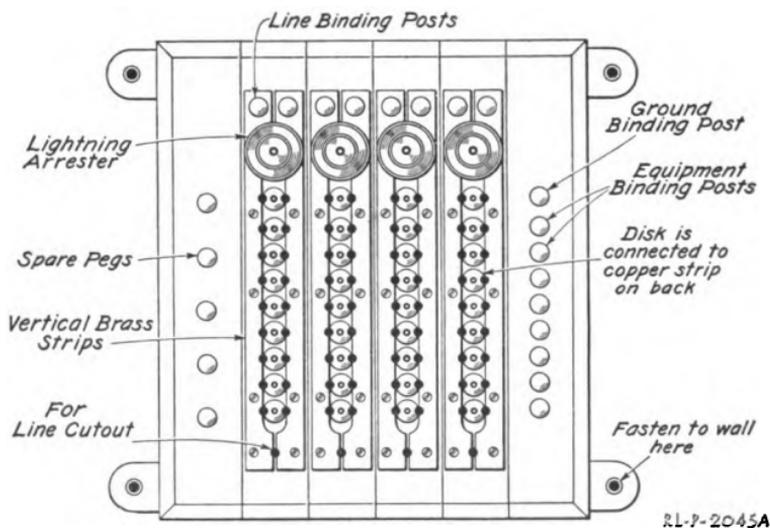


FIGURE 68.—Switchboard BD-50 (front view).

■ 171. OTHER SWITCHBOARDS.—Various other switchboards and associated equipment of commercial design are employed. Switchboards BD-52 and BD-53 are single-spring jack types of 8- and 20-line capacities, respectively. Other spring jack

types of 6- and 10-line capacities, and pin types of 1, 2, 3, 6, 10, 11, 12, and 40-line capacities are available. For further information, see Signal Corps General Catalog.

■ **172. PATCHING.**—By patching is meant any change of line-circuit connections which will result in a new routing of line circuits already established. Patching is resorted to when sections of some line circuits are in trouble and when the volume of business changes. It is frequently the case that several line circuits pass through an office which is equipped with but two or three instruments. In this case the line circuits having no instruments are connected through the

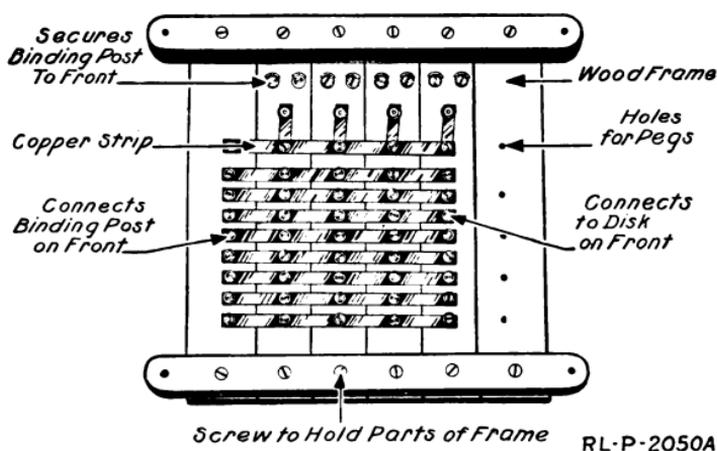


FIGURE 69.—Switchboard BD-50 (rear view).

station. With the peg-type telegraph switchboard these connections are made by moving the pegs to such holes as will give the desired connection. With the pin-jack type of switchboard the changes are made by connecting the new circuits together with patching cords and then removing the patching cords which made up the old connection.

■ **173. POWER PLANTS.**—In a large office it is desirable to have at least three voltages available, two for line use and one for use on local circuits. The line batteries are of opposite potentials (one with the positive terminal grounded and the other with the negative terminal grounded), and the maxi-

imum voltage is determined by the longest line terminating at the office. The local battery is usually of 26 volts and is used to operate sounders and other office apparatus. This battery has its positive terminal grounded. The word "battery" is used in a broad sense, for the required voltages may be obtained from gasoline engine or motor-driven generators or from suitable rectifiers operating on commercial alternating current. All voltages to the lines are supplied from a common bus through a 2-ampere fuse and through a resistance of from 2 to 3 ohms per volt to prevent damage in case of a short circuit.

■ 174. SINGLE-LINE REPEATERS.—Single-line circuits are limited in length by the leakage and resistance of the line. Where it is desired to operate over extreme distances, *repeaters* must be installed at intervals along the line. A repeater cuts a line into two electrically dissociated sections, but repeats signals between the two sections just as if the line were continuous, each section then having the good operating characteristics of a short line. The type of repeater in most common use is the shunt-locking repeater (fig. 70). The connection from a line battery to the repeater is called a *repeater leg*, and a set may be cut into this leg for testing purposes or for supervision. When the two lever switches on the base of the shunt-locking repeater are thrown outward, the repeater is said to be *cut*; that is, signals are not repeated from one section of the line to the other, but each section of the line may be worked separately from the repeater station by the set in the repeater leg. When the two switches are thrown toward each other, signals are then repeated between the two sections of the line, although no direct electrical connection exists between them.

■ 175. TELEGRAPH PRINTERS.—*a. General.*—In discussing the closed-circuit telegraph system (par. 164) it was assumed that the transmitted signals were produced manually by hand operation of an ordinary telegraph key. A large percentage of telegraph circuits is operated by mechanical devices known as telegraph printers which are installed at stations in place of the keys and sounders of manual practice. Although decisions

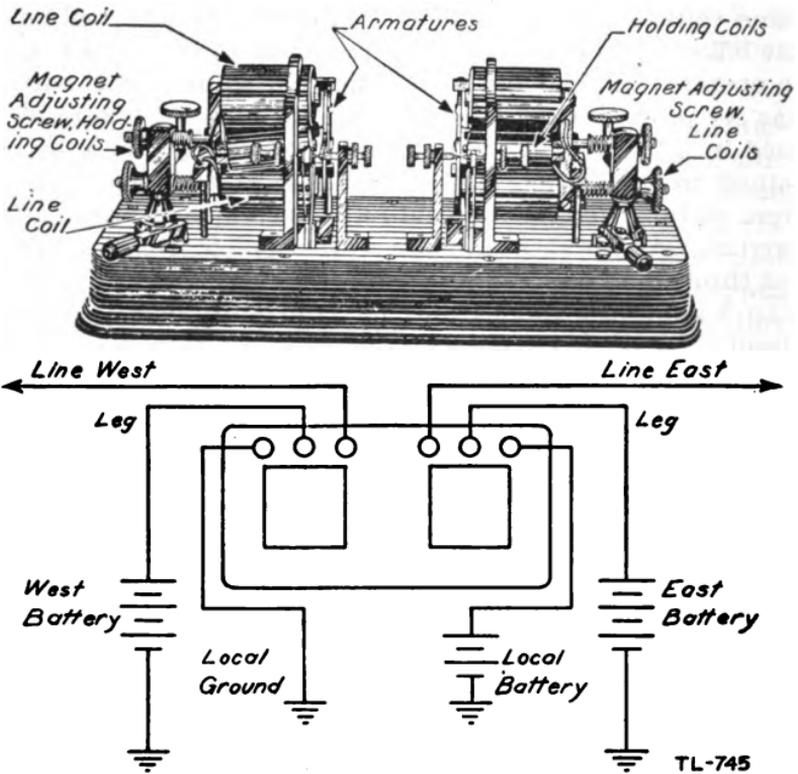


FIGURE 70.—Double shunt-locking repeater with external wiring diagram.

as to military standardization and basis of issue of telegraph printers have not been made, use thereof may be expected at division and higher headquarters.

*b. Description.*—(See fig. 71.) Usually the telegraph printer consists of a keyboard similar to a standard typewriter keyboard and a typing or printing mechanism designed to print received messages either on a page, as is done with typewriters, or on a tape in the manner of stock quotation tickers. At stations where receiving service only is desired, the keyboard may be omitted. At stations where a large volume of outgoing traffic is desired, a more elaborate sending mechanism is installed, with which messages are first recorded by perforating a tape and then transmitted from the tape.

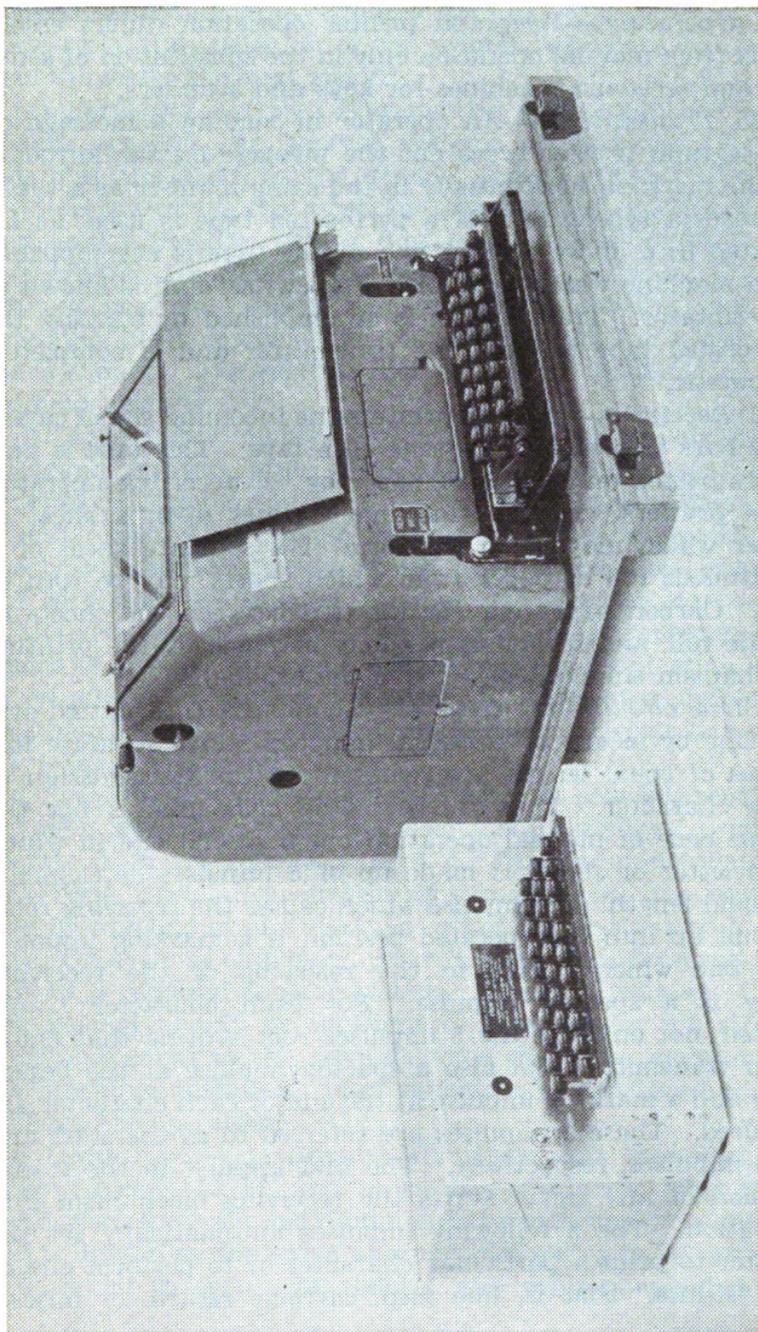


FIGURE 71.—Telegraph printers.

*c. Operation.*—Telegraph printer operation differs essentially from manual operation only in the substitution of sending and receiving machines for keys and sounders.

(1) *Transmitting.*—An operator in sending a message on a telegraph printer types out the message on the keyboard of the machine substantially in the same manner as a typist operates a typewriter. If a perforated tape is used, as indicated in *b* above, the cutting of the tape is accomplished on a machine which resembles a typewriter and is known as a perforator. Transmission is accomplished by starting the perforated tape through the transmitter and is completely automatic.

(2) *Receiving.*—On tape printers the incoming signal causes type bars to print the message on a tape. This tape is normally pasted on a sheet of paper by the receiving operator. Page printers write the message in lines upon a sheet of paper which may be in the form of a separate sheet or a continuous roll of paper from which sheets may be torn at will. Carbon paper may be inserted between the sheets or in the roll, and several copies may be made by the printing mechanism simultaneously with the original.

*d. Line circuit.*—(1) *General.*—Signals are transmitted over the line by means of electrical impulses. Five separate impulses of equal length are required for the transmission of each character. Thus the signaling code used is not the Morse code of manual operation but a special one in which each letter or signal is made up of 5 impulses or elements of equal length. An impulse which causes the receiving relay to pull up into the operated position is a marking impulse, and one which results in the releasing of the receiving relay is a spacing impulse. For each character transmitted, not only are the 5 impulses representing that character transmitted, but also a spacing impulse at the beginning and a marking impulse at the end of each character are required. These 2 impulses are referred to as the start and stop impulses, respectively. The first impulse in the transmission of any signal starts the receiving mechanism into operation. The 5 following impulses automatically set the printer to print a particular character or to perform one of the "stunts," that is, line feed, carriage return, or miscel-

aneous switching and signaling actions. The seventh impulse stops the operation of the printer, placing it in readiness to receive the next signal.

(2) *Signaling systems.*—The neutral system and the polar system are the two general systems of transmitting signals over the line. In the neutral system, current flows in the line to operate the receiving relays to the marking position, and when the current flow is stopped by opening the line circuit, the relays are mechanically returned to the spacing position. Polar transmission is accomplished by changing the polarity of the sending battery for mark and space signals. The neutral system is more suitable for use on field circuits.

(3) *Line requirements.*—For most satisfactory operation, telegraph printers when used without auxiliary relays are generally restricted to use on short, well-insulated lines. In general, field wire circuits of over 12 miles in length, or poorly constructed circuits which have appreciable leakage, will so distort transmitted signals that misprints may occur in the received message. Through the use of repeaters the length of circuit over which satisfactory communication may be established is greatly increased. The use of a simplex telephone circuit is feasible if the telephone circuit has very low leakage to ground.

*e. Power requirements.*—A local source of power is required for each separate printer installed. Most types of printers operate from 110 volts, a. c. or d. c. In printer installations employing the neutral system of transmission, line battery may be supplied at any one or at all of the stations on a circuit. On systems employing polar transmission, however, line battery is required at each station. The total voltage of the line battery should be sufficient to establish in the circuit a current equal to the recommended operating current for the machines installed. Most machines are designed for 60 milliamperes operation.

*f. Limitations.*—(1) *Speed.*—There are three standard operating speeds, 40, 60, and 75 words per minute. This word speed represents the maximum speed which can be attained and is limited by the speed at which the motor in the printer is designed to turn. In general, the printers selected for

operation on a given system should have a maximum speed based on the condition of the line circuits over which transmission is to be effected. The shorter and better the line circuit, the greater may be the maximum speed of the printers selected.

(2) *Number on one circuit.*—The number of printers in service on a single telegraph loop circuit should not exceed 5. Through the use of a suitable switchboard and repeaters, however, any one of the stations connected to the switchboard may transmit to all other stations connected to the board or establish two-way communication with any one of the other stations.

(3) *Maintenance.*—The proper maintenance of telegraph printers requires a highly trained technician. In general, operators should be forbidden to effect any repair to the equipment which they operate. An unserviceable printer should be replaced by a serviceable one, if available, and the necessary repairs accomplished at a repair shop. Telegraph printers when handling heavy traffic loads continuously should be given a routine inspection and adjustment every 10 days. This inspection and adjustment which must be accomplished by maintenance personnel is usually done at the point of installation of the printer. Lighter traffic loads necessitate less frequent routine adjustments.

*g. Signaling features.*—(1) *Remote control start-stop.*—Telegraph printers may be equipped with a remote control feature which will permit one station to place the printer of a distant station into operation even though the printer motor at the latter station has been shut down. This feature enables a printer to receive a message even though the operator of the receiving printer is not at his station. Without this feature, printer motors must turn continuously if the printer is to be in readiness at all times to receive signals. Printers connected to a switchboard frequently contain a feature which closes the line circuit when the printer motor is turned on, lighting a lamp signal on the switchboard. If the motor on a printer not equipped with this remote control is shut down and the printing mechanism is thereby placed in an inoperative condition, the line relay on this printer may still be operated from the distant station, and

the clicking of the line relay may attract the attention of the receiving operator and cause him to place the printer in operating condition.

(2) *Auxiliary signaling equipment.*—When telegraph printers are connected to telegraph printer switchboards, the use of auxiliary signaling circuits is advisable. At each printer station a bell box is installed, the bells in which may be operated from the switchboard to signal the printer station.

■ 176. MULTICHANNEL TELEGRAPHY.—*a.* Telegraph circuits in rear areas are run over more or less permanent open wire and cable lines which are very efficient. The use of multi-channel circuits over these lines is desirable and in many cases is almost mandatory, especially over long distances.

*b.* The ordinary multichannel telegraph systems in use are the differential duplex, the bridge duplex, the Morris duplex, and the multiplex printing telegraph. By duplex is meant a system providing for simultaneous traffic in opposite directions over a single circuit.

■ 177. DIFFERENTIAL DUPLEX.—*a.* The differential duplex shown in figure 72A is of the double-current type; that is, two polarities of line battery must be available at both terminals. The heart of this system is the differential polar relay, DPR—differential because it operates on the difference of the currents flowing in its two windings, and polar because the direction of the difference of these currents determines against which pole the magnetized armature will be drawn.

*b.* From the key K which applies positive or negative line battery to the apparatus, the circuit is seen to divide, one branch passing through one coil of the relay to the line and down through the distant station apparatus to ground, while the other branch also passes through a relay coil but goes through a combination of resistance and capacity, called the artificial line AL, to ground. The artificial line resistance is made to equal the line resistance plus the resistance of the equipment at the other end of the line, and its capacity is balanced against the capacity of the line. If both keys are marking, no current flows in the line since both keys are applying negative battery to the line. However, current flows from ground through the artificial lines and through one-

half of each relay which throws the relay armatures to the marking position. If both keys are spacing, no current flows in the line, but current flows from battery through one-half of the windings of each relay through the artificial lines to ground, current flow being in such directions as to throw the armatures to spacing position. When one station is marking and one is spacing, the batteries aid each other; the line current is about double the artificial line current in each relay, and the direction of each relay is such that the relay position corresponds to the key position at the far end.

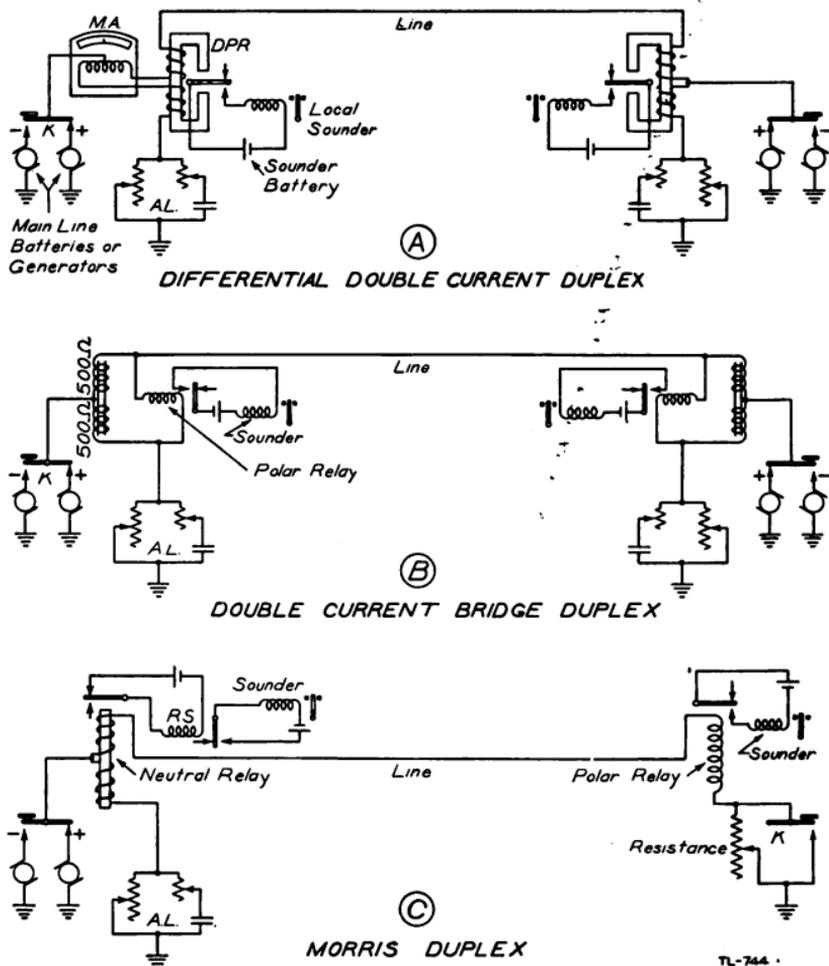


FIGURE 72.—Duplex circuits.

c. To arrive at a balance, a differential milliammeter is used. This milliammeter is indicated at MA and reads the difference in currents of the two relay windings. A constant reading is obtained due to the unbalancing effect of the distant battery. The direction of this reading depends on the position of the distant key. The artificial line is adjusted until no change is noted in the milliammeter reading when the near key is operated.

■ 178. BRIDGE DUPLEX.—*a.* The bridge duplex is shown in figure 72B. It is seen that the current from a station's own battery is divided in the same way as in the differential duplex, and balance is arrived at in the same manner. In this case, however, the division into the line and artificial line branches is accomplished through a split inductance of 1,000 ohms, instead of through the two coils of a differential relay; and a plain polar relay is placed across the ends of the coil. When one station is marking and the other is spacing, the line current is nearly double the artificial line current and both relays are operated due to the current unbalance, the relay positions corresponding to the key positions at the distant ends. If both keys are in the marking or both in the spacing position, no current flows in the line, but current flows in the artificial line. Consequently, both relays are put in the marking or both in the spacing position depending on the current direction in the artificial line side of the coil, which in turn depends upon the distant key positions.

*b.* The bridge duplex requires more apparatus than the differential duplex, but is less susceptible to line disturbances and is more satisfactory over cable systems.

■ 179. POLE CHANGERS.—*a.* An open-circuit key such as shown in figure 62 utilizes both back and front contacts, and is not always satisfactory in that fast operators may not make positive contact at the rear when releasing the key. To insure a quick and positive change from one polarity to the other, a pole changer is used. The pole changer is merely a 2-contact relay operated by a local battery in a circuit with a single contact key. When the key is closed, the pole changer coil is energized and the armature is drawn up against the negative

contact. Likewise, when the key is released the armature falls back against the positive contact.

b. Both the differential duplex and the bridge duplex are easily repeated over sections of a long line, it being only necessary to install terminal duplex apparatus on the ends of each section of the line, and to use each relay as the pole changer of the other line. Thus any signal coming in on one section of the line operates its relay in the usual manner, and the relay tongue receives the polarity of potential from the contact against which it is drawn and applies it to the next section of the line sending the signal on.

■ 180. MORRIS DUPLEX.—The Morris or short line duplex (fig. 72 C) is used on short lines where no line battery is available at the far end, or where it is desirable to have a minimum of equipment at the far end. At the battery end the battery is connected to the midpoint of a neutral relay. The armature of this relay is drawn up whenever more current flows in one winding than in the other, regardless of the direction of this difference. A resistance equal to twice the line resistance is inserted in the line at the far end, and the artificial line is adjusted so that the line current is equal to the artificial line current at the battery end and the neutral relay does not operate. Now, when the key across the resistance at the distant end is closed, the line current is trebled and the neutral relay is operated. Operating the key at the battery end changes the direction of the line current, thereby operating the polar relay at the far end. It is almost mandatory to have a pole changer at the battery end instead of a pole-changing key, for if there is delay in moving the key from one contact to the other there will be no current in the line, and the armature of the neutral relay will fall back if it has been drawn up. Even with a pole changer the armature will fall back slightly on reversals of current, so it is made to work on its back contact. In this case a slight falling off of the armature will fail to make contact at the rear contact and no false signal will result. However, the signals are now reversed and must be corrected by the action of a repeating sounder also working on its back contact. This repeating sounder RS opens and closes

the circuit of the reading sounder which produces the correct signals.

■ 181. MULTIPLEX TELEGRAPHY.—Multiplex telegraphy is a combination of automatic transmitters and printers operating in synchronism and providing from two to four duplex channels over a single circuit. The terminal apparatus is complicated, hard to install, and expensive. Hence this system is used in permanent installations where trunk traffic is very heavy and lines are at a premium. When used, it conforms to commercial practices.



## APPENDIX

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