Declassified E.O. 12065 Section 3-402/NNDG NO. 775009

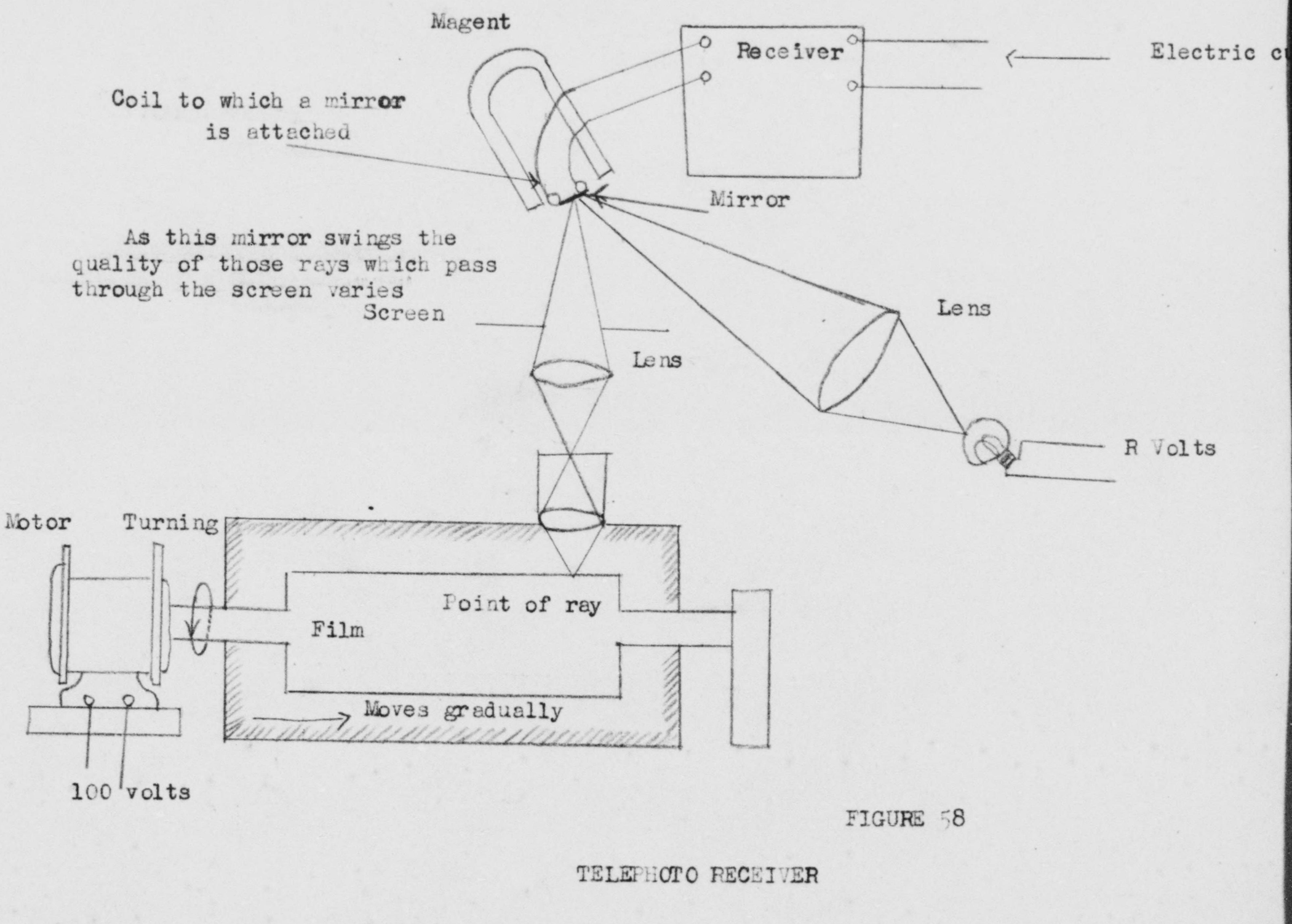


FIGURE 58

TELEPHOTO RECEIVER

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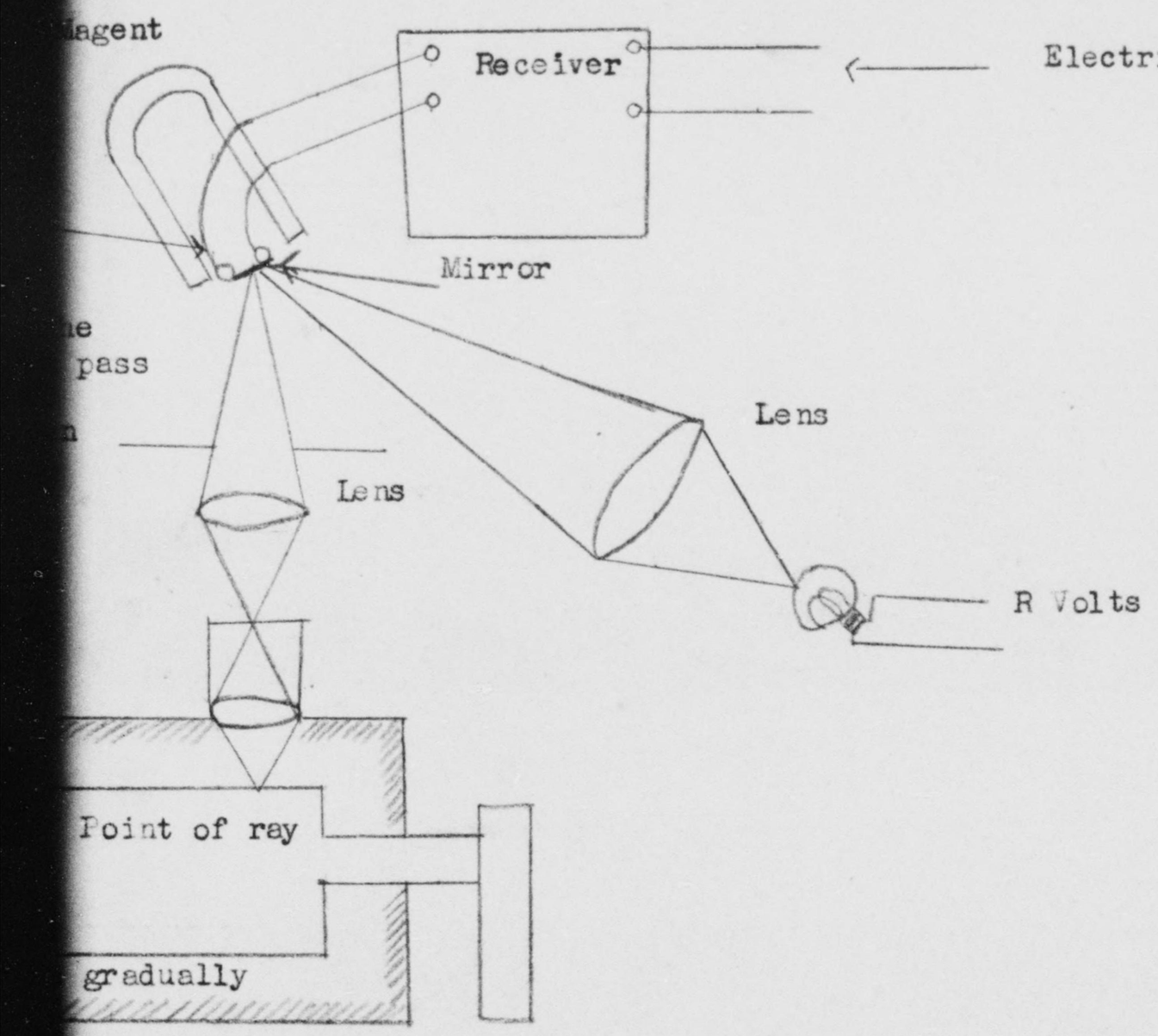


FIGURE 58

TELEPHOTO RECEIVER

aperture into the camera obscura and directed towards the surface of the photograph. When the rays are focused and the diameter becomes about one-sixth of a millimeter, the rays strike the photograph and are reflected. Then, the reflected rays pass through a dark cylinder and come into contact with a photo-cell on the right side. Upon examining the reflected rays at this point if the surface of the photograph is smooth. The rays striking the light area are practically all reflected while those striking the dark area are almost all absorbed and few rays are reflected. Therefore, the rays that come into contact with the photo cell are weak if they had struck dark areas. In other words, the lighter the area, the stronger the reflection.

Furthermore if the shade of the photographs surface is moderate rays of medium strength corresponding to the shade of the area where the rays strike are reflected to the photo cell and altered to various strengths of electric current. In short, the principle of the telephotography is:

(a) To break down photographs into series of light rays of varying intersities (called scanning process).

(b) To convert the varying intensities of light rays into electric current.

If the half tone engraving of a newspaper photograph is studied carefully one will notice the photograph is made up of small black dots. Parts where the dots are concentrated are black while areas with no black dots appear white. In other words, when these extremely small black and white dots are combined they form a photograph (Fig. 57). A photograph being a combination of these extremely minute dots the principle of telephotography and television is, therefore, to break it down into white and black dots and transmit them one by one and then recombine them to reform the original photograph. These dots are called "picture elements". Directing the finely focused rays on the surface of a photograph and then reflecting them to come into contact with the photo-cell is the process undertaken to transmit one of these picture elements.

However, even in the transmission of these picture elements, there is a regular procedure. In the same manner that we read from left to right and from top to bottom and then proceed from line to line until the page is completed, the rays are directed on the surface of the photograph in like manner. This breaking down of a photograph into picture elements and then transmitting them in order is called "scanning". Since it is necessary to transform the electric current according to the darks and lights

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If the rays are from the light area of the photograph, the rays which strike the photo-cell are strong accordingly, much electricity flows within the photo-cell. If the rays are from a dark area, little electricity flows since the rays are weak. As the photograph is scanned, light areas as well as dark areas appear, therefore, the flow of electricity within the photo-cell increases or decreases accordingly. After the electric current is amplified by a vacuum tube, it is transmitted from the transmitter by wire or waves.



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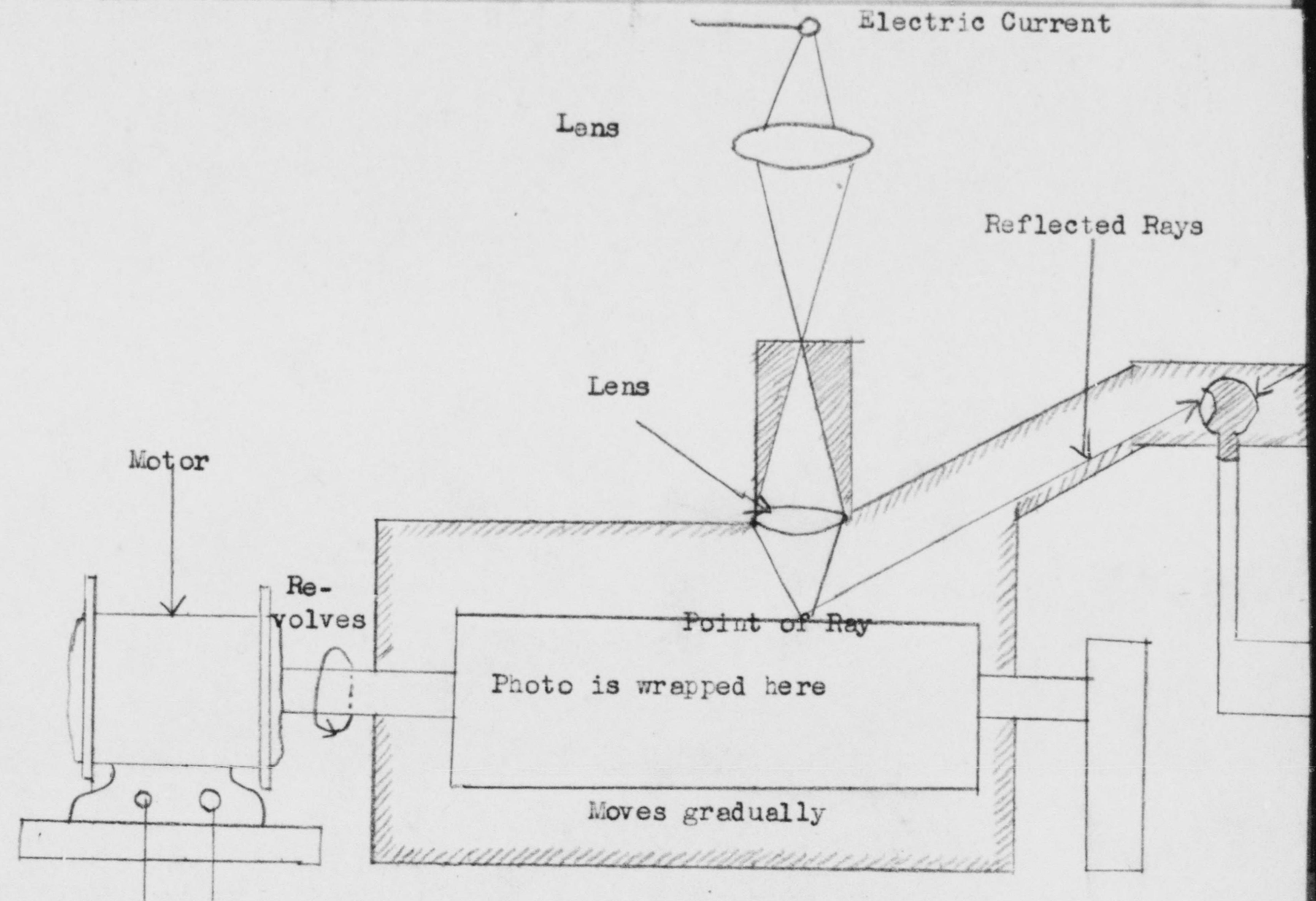
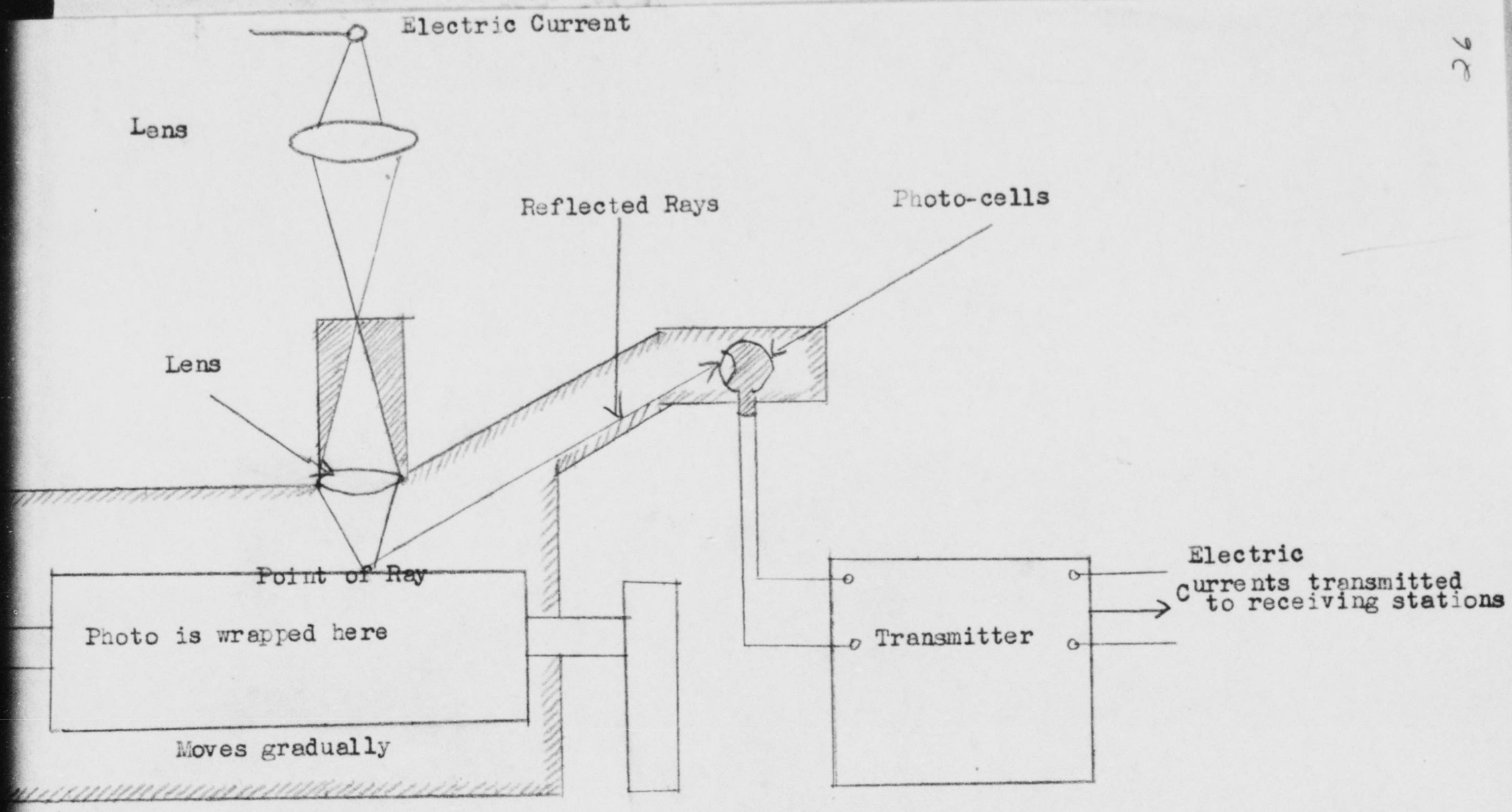



Picture No. 56
Telephoto Transmitter

Declassified E.O. 12065 Section 3-402/NNDG NO. 775009






Picture No. 56
Telephoto Transmitter

different and special code system is employed. In printing telegraphy symbols corresponding to the wording of a message are perforated on a tape with a perforator and the tape is inserted into a printing telegraph transmitter and when the symbols are transmitted, the receiver automatically prints words corresponding to the symbols.

The merits of printing telegraphy lay in that there is no need to memorize special codes since only the necessary keys of the transmitter need be struck like a typewriter and in the fact that the recipient only has to cut the tape to the proper length and paste the pieces on the telegram form as the words appear on the tape (Fig 55 (a)). In Japan printing telegraphs are used only in telegraph offices but in the U.S. Government offices, companies, newspaper offices and even some homes are equipped with printing telegraph sets which are operated by telephone wires, thus making printing telegraph practically a subscriber telegraph. In Japan however, this is quite impossible, for the number of characters are so numerous that only the KANA and figures can be employed.

(2) Facsimile Telegraph

Whereas printing telegraphy apparatus can transmit and receive only certain characters, facsimile telegraphy is still more developed and is able to transmit and receive Chinese characters, graphs, pictures and handwriting. Of course, there is a considerable difference between the principle of printing telegraphy and that of facsimile telegraphy. The latter is far more advanced. (Fig 55 (b)).

Since the principle of fascimile telegraph is the same as that of telephoto graphy which is explained later, it will be explained in detail in the next paragraph. The only difference between the two is that in telephotography printing paper or film is used while in facsimile telegraph, the image which is transmitted is reproduced in the same form on ordinary blank paper. Furthermore, since only black and white can be transmitted or received in facsilile telegraphy, it is especially adapted for transmitting and receiving characters, graphs, etc. For distinguishing delicate shades, better results are obtained by using telephotography.

(3) Telephotography

Telephotography is a method of communication by which the changes in the color (black and white) of an object (photo-

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for the number of characters are so numerous that only the KANA and figures can be employed.

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(3) Telephotography

Telephotography is a method of communication by which the changes in the color (black and white) of an object (photograph, writings, etc) are reflected and transformed into electric currents through continuous exposure to photo cells and transmitted a long distance. The said electric current is reverted back to color with photo cells again and exposed on film or printing paper to produce the image. Telephoto apparatus consists of a transmitter receiver and a circuit.

1. Transmitter.

To explain the transmission process of a telephoto machine according to Fig. 56 (NE - method); first, the photograph to be transmitted is wrapped around the surface of the cylinder inside the camera obscura located on the lower part of the machine. The rays from the electric lamp (about 150 watts) above the machine are then focused by means of lenses and admitted through a small



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Because the above process is repeated over and over again, a voltage which is several to several tens of time stronger than the original high frequency voltage is generated in the tuning coil, and the sensitivity of the receiver is heightened considerably. This process is called regeneration and the receiver to which the wave-detecting method of the said process is applied is referred to as the regeneration type. The autodyne type receiver receives A1 electric waves by permitting wave detection and oscillation processes to take place simultaneously in one of the vacuum tubes. Being simple in structure and easy to handle, this receiver is popular. However, low stability is one of its defects. In the super hetrodyne type receiver, oscillating current is generated by the local oscillator within the receiver and the inter-mediate frequency which is generated as a result of the wave-detection of the humming which is produced from the oscillating electric current and receiving electric wave is amplified many times, strengthened and re-detected. This receiver is excellent for separating interference and receiving feeble modulated electric waves. Therefore, nearly all high-grade receivers rely upon the super-hetrodyne method. Beside those mentioned above, there are other receivers such as the amplitude modulation receiver and the frequency-modulation receiver which rely upon the modulation method, the direct current receiver and alternating current receiver which rely upon different types of power and long-wave receiver, medium wave receiver, short-wave receiver and the ultra-short wave receiver which depend upon the frequency of the receiving wave.

3. Power Source

Direct current receivers which are operated by batteries have long been in use. However, because A, B, C, and various other batteries are necessary, today, their use is mostly confined to areas where the supply of electricity is limited. Generally alternating current receivers which work with alternating current from lamp cords are used. A source of electricity uses alternating current as is, B source of electricity changes alternating current into direct current with a rectifier tube (vacuum tube) while the C source of electricity uses the voltage drop caused by the plate current as is, without any special equipment except for the combination of a resistor and condensor. Since the voltage of alternating current necessary for the A source of electricity is generally for below 100 volts, while that of B source exceeds 100 volts, a small transformer like the one explained in Chapter II Section I is used to supply these power sources with the proper amount of alternating current.

Section Four: Telephoto Apparatus, Etc.

All the communication facilities explained up to now rely

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**Section Four:** Telephoto Apparatus, Etc.

All the communication facilities explained up to now rely upon sound to transmit communication. In other words, voice or sound codes are transmitted to the ears of the recipient. However, with the gradual improvement of communication facilities, there rose a demand for communication by sight which lead to the invention of printing telegraph, facsimile telegraph and telephotograph.

Lately, even television is being put to practical use.

(1) Printing Telegraph

In both manual telegraphy and automatic telegraphy which were explained before in connection with wireless communication, the Morse Code is used. In printing telegraphy, however, an entirely



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Typing

20 Sept

Declassified E.O. 12065 Section 3-402/NNDG NO. 775009

To _____

Date _____ Time _____

# WHILE YOU WERE OUT

of _____

Phone _____

| | | | |
|---|---|---|---|
| TELEPHONED | | PLEASE CALL HIM | |
| CALLED TO SEE YOU | | WILL CALL AGAIN | |
| WANTED TO SEE YOU | | RUSH | |

Message _____

REPRO BY 64TH ENGR TOPO BN

Declassified E.O. 12065 Section 3-402/NNDC NO. 77509

# CHAPTER III

## RADIO COMMUNICATION FACILITIES

Declassified E.O. 12065 Section 3-402/NNDC NO. 775009

Section One: Introduction

Part One: Electric Communication Facilities

All facilities, materials, office tools and machines, buildings and other paraphernalia attached to these which rely upon electricity for communication are called tele-communication facilities.

Part Two: Types

Electric communication facilities can rougly be classified into: wire and wireless communication facilities. Wire communication facilities denote those which rely upon wires for communication, and wireless communication facilities those which communicate by electric waves rather than by wires.

Wire and wireless communication facilities can, according to the telegraph and telephone methods employed be divided into, either wire telegraph and telephone or wireless telegraph and telephone. Telegraph is a form of communication under which electric currents altered by signals are transmitted or received and reproduced. In contrast, with telephone communication, air vibration of voice is transformed into electric currents and transmitted or received and reproduced. Since special codes are used in telegraph communication, not only are technicians necessary in the sending and receiving of communication, but the working speed is also reduced. On the other hand, in telephone communication direct sound is transmitted by electric currents and the fundamental tone is reproduced by the receiver, therefore, the contents of the communication is adequately transmitted and high speed communication is possible.

The following table lists some of the electric communication facilities:

| | |
|---|---|
| Wire Communication Facilities | Wire Telephone |
| | Wire telegraph |
| | Wire telephoto (Electric Transmission) |
| | Wire facsimile telegraph |
| | Wire television |
| Wireless Communication Facilities | Wireless telephone |
| | Wireless telegraph |
| | Wireless telephoto |
| | Wireless facsimile telegraph |
| | Wireless television |

Part Three: Communication Net

Since the purpose of

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| | Wire facsimile telegraph |
| | Wire television |
| Wireless Communication Facilities | Wireless telephone |
| | Wireless telegraph |
| | Wireless telephoto |
| | Wireless facsimile telegraph |
| | Wireless television |

Part Three: Communication Net

Since the purpose of communication is to establish contact between two points, communication facilities are dispersed over wide areas. These areas are connected with one another by mems of wires or electric waves and perform as one body in transmitting communication. A group of communication facilities connected with one another by wires or by electric waves and which act as one body in transmitting communication is called a communication net. The organization and types of communication net are as follows:

1. System

A communication net is connected by wires or electric waves and form a definite system by which communication is conducted.



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This system spreads out from the center to the mid-center in the shape of a fan, and then from the mid-center towards the outer network again in the shape of a fan. As the network approaches the outer extremes, the meshwork becomes finer. The form of the network is determined by purpose of the given communication facilities. For instance, the system of public communication net connects important cities in response to domestic political and economic needs as well to the activities of the people and the nation. In a city the center of the net is in one or more telephone offices and extends to homes, companies, banks, stores, government offices, etc. Thus, a communication system is determined by the objective of the facilities.

Within the system itself there are two kinds, i.e. broadcasting and communication. A broadcasting system transmits simultaneously messages from a fixed central station to numerous special or non-special branch stations which only receive. With the communication system, two stations receive as well as transmit messages. These two stations can be further divided into fixed and mobile communication systems. A fixed communication system is a system between fixed stations, while a mobile communication system connects a fixed station with cruising automobiles, bicycles, trains as well as moving ships, warships (mobile stations), or two mobile stations. Radio comes under the broadcasting system, telephone under communication system, while a radio car comes under the mobile communication system.

2. Types

There are various kinds of communication nets such as public communication net, police communication net, railway communication net, weather communication net, etc., according to the purpose of the communication facilities. Communication facilities may also be divided into different classifications, such as wire telephone net, wireless telephone net, and facsimile transmission net, etc. These communication nets are exceedingly complex. Some are duplications while others are interlinked. But as a rule, each is independently organized.

Section Two: Wire Telephone Apparatus

Part One: Definition of Wire Telephone Apparatus

Wire telephone equipment consists of various apparatus which change the sound waves generated by a talker into electric vibration, transmit the vibrations through wires to distant points and reproduce the fundamental tones as original sound waves.

The apparatus consists of telephones, wires, switch boards

system, two stations receive as well as transmit messages. [illegible] two stations can be further divided into fixed and mobile communication systems. A fixed communication system is a system between fixed stations, while a mobile communication system connects a fixed station with cruising automobiles, bicycles, trains as well as moving ships, warships (mobile stations), or two mobile stations. Radio comes under the broadcasting system, telephone under communication system, while a radio car comes under the mobile communication system.

2. Types

There are various kinds of communication nets such as public communication net, police communication net, railway communication net, weather communication net, etc., according to the purpose of the communication facilities. Communication facilities may also be divided into different classifications, such as wire telephone net, wireless telephone net, and facsimile transmission net, etc. These communication nets are exceedingly complex. Some are duplications while others are interlinked. But as a rule, each is independently organized.

Section Two: Wire Telephone Apparatus

Part One: Definition of Wire Telephone Apparatus

Wire telephone equipment consists of various apparatus which change the sound waves generated by a talker into electric vibration, transmit the vibrations through wires to distant points and reproduce the fundamental tones as original sound waves.

The apparatus consists of telephones, wires, switch-boards, safety devices, wire distributing panels, testing equipment, and apparatuses for electric power generation. Besides these, there are special apparatuses such as telephone repeaters, carrier telephone equipment, simultaneous address telephone equipment and privacy system apparatus.

Part Two: Telephone Set

A telephone set consists of a transmitter, receiver and signalling apparatus. The transmitter and receiver are the most important parts of telephone equipment.

(1) Transmitter. A telephone is an instrument which



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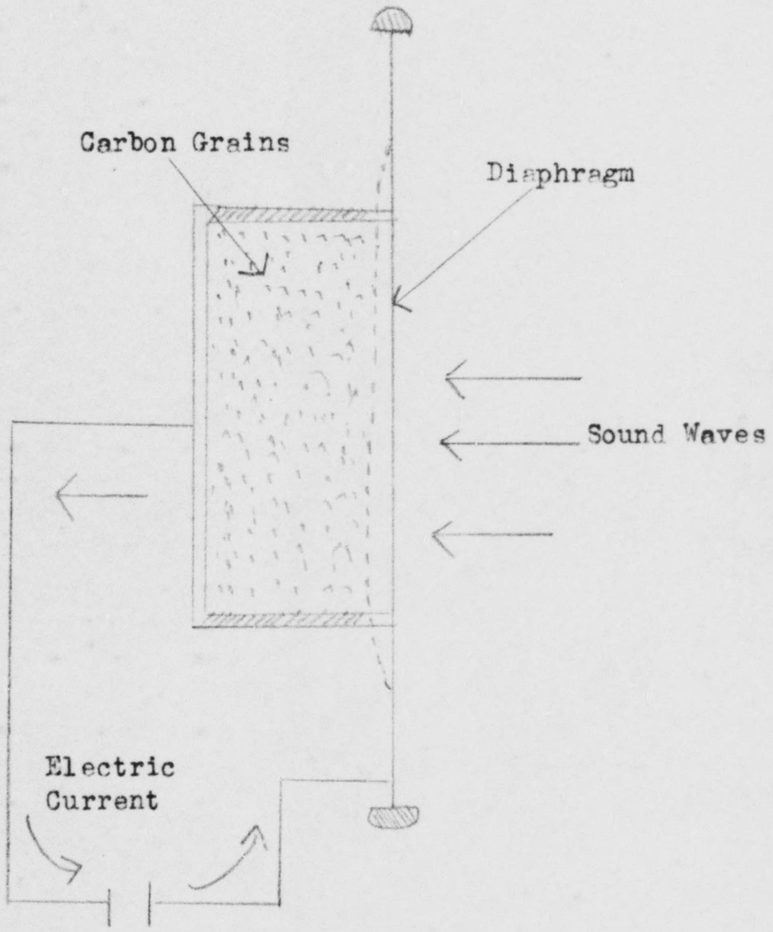
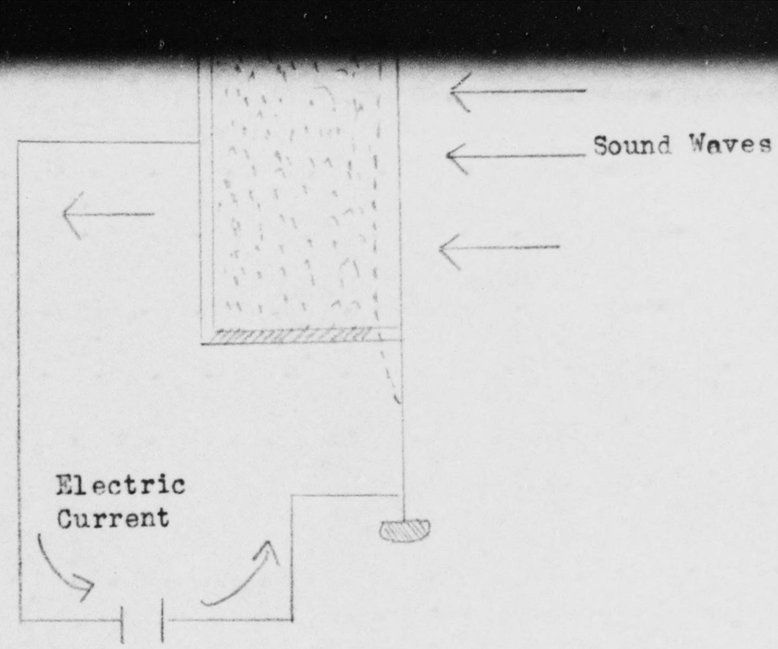



Theory of Transmitter

FIGURE 33




Theory of Transmitter

FIGURE 33



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carries voices a long distance in the form of electric currents, and after the currents reach the destination, it changes them back into voices. The function of a transmitter is to change human voices into electric currents.

For this the transmitter is equipped with a diaphragm which vibrates according to the sound of our voices. To change voices into electric currents, the box behind the diaphragm is filled with carbon grains (Fig. 33). Since carbon is a good conductor of electricity, when a battery is attached to both sides of the carbon box, electric current begins to flow through the carbon grains. However, the strength of flow of the electric current varies according to how the box is filled. That is to say, if the box should be filled loosely, there is less adherence between the grains of carbon and thus greater resistence, consequently, the passage of electric current is made difficult. On the other hand, tightly packed grains offer little resistence and provide excellent passage of electric current. In other words, the ratio of the electric current which passes through the carbon is in proportion to the pressure applied to the carbon grains.

Accordingly, when one speaks into the transmitter after a battery is connected to the box containing the carbon grains behind the diaphragm and electric current is permitted to flow, the diaphragm vibrates. With each vibration, pressure is applied or released from the carbon grains. The flow of the electric current also becomes stronger or weaker with each vibration.

(2) Receiver

A receiver is an instrument which reverts the telephonic current sent from the transmitter back into sound and sends the sound as voice into the ear. But it is still the diaphragm of the receiver which produces the sound, and in order to produce vibration of the diaphragm with electric current, an electromagnet is used. As is shown in Fig. 34, a piece of wrought iron is attached to each end of the two poles of the horseshoe-shaped permanent magnet. A coil is wound around the wrought iron, and a diaphragm is placed in front of the two ends of the wrought iron. Drawn by the force of the permanent magnet, the diaphragm is usually in a curved form. However, when electric current is sent through the coil, the wrought iron becomes an electromagnet, and the combination of its force with the magnetic force of the permanent magnet alters the force that has been pulling the diaphragm. When the electric current which is constantly being changed by the transmitter flows through the coil, the diaphragm vibrates to and fro, aided by the force which pulls it and produces an audible sound.

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(3) Signalling Apparatus

The signalling apparatus consists of a magnetic dynamo and electric bells and is a device which calls the correspondent or signals that one is being called (Fig. 35).

(4) Classification of Telephone Set

A telephone set is either a magnetic system or a common battery system. The difference lies in whether each subscriber is equipped locally with a transmitting battery or whether the batteries of all the subscribers within the subscriber area are installed at the telephone office and used jointly (Fig 36).



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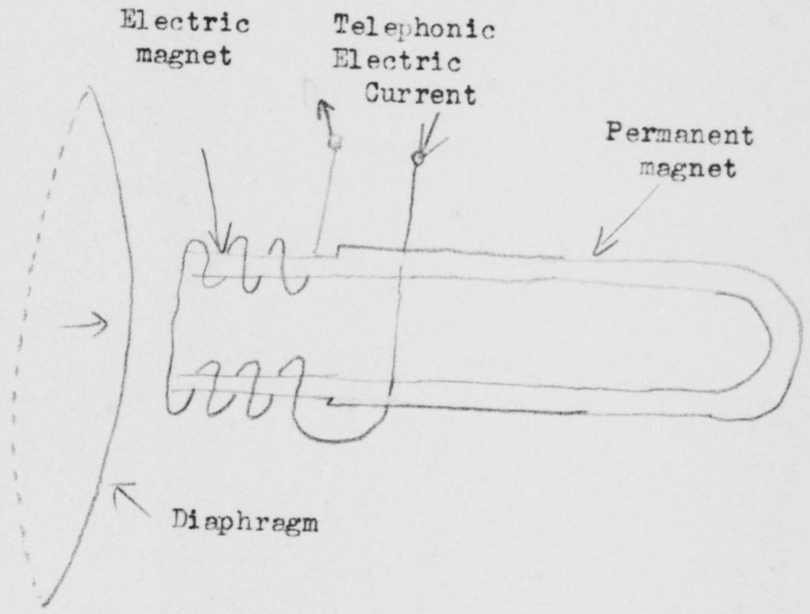


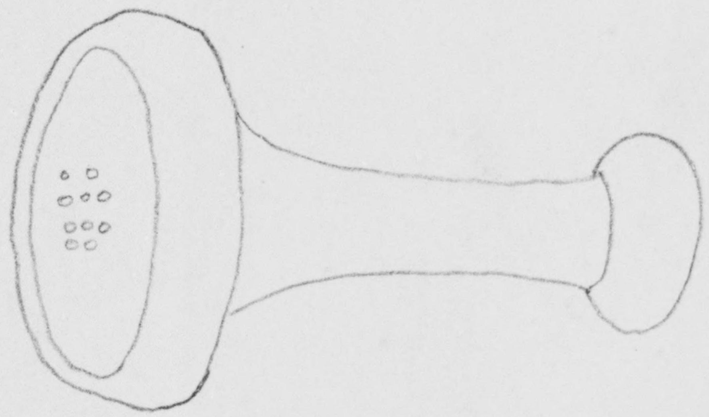

When telephone current passes through the electra-magnet, the diaphragm vibrates and produces audible sounds.

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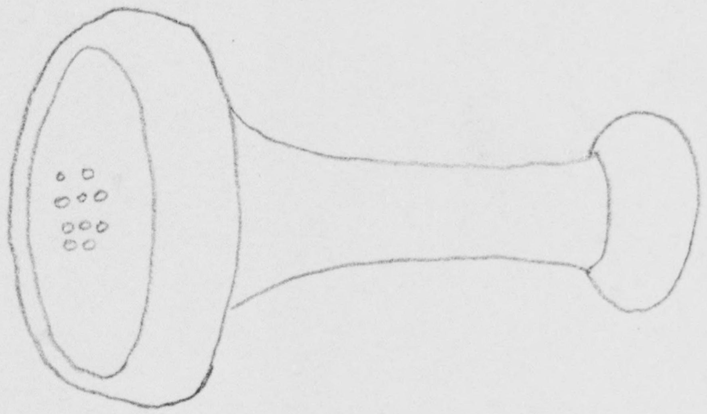

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FIGURE 34



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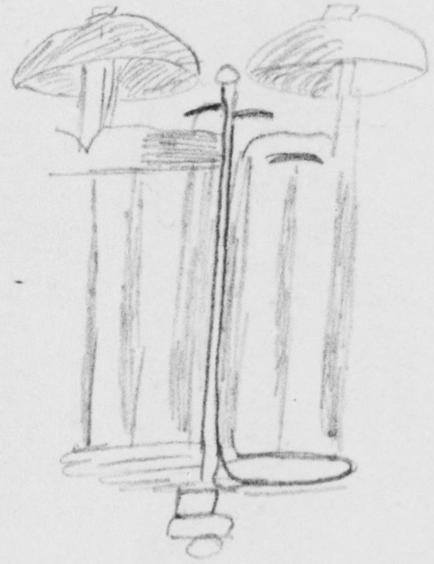

Signalling Apparatus

FIGURE 35

Signalling Apparatus

FIGURE 35



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(By subscriber area is meant telephone sets which receive calls through the same switchboard or telephone office).

The magnetic system telephone is equipped with the above mentioned signalling apparatus, but in the common battery system telephone, the call sign is automatically transmitted to the telephone office when the receiver is taken off the hook. Needless to say it is also equipped with an electric bell which signals one whenever he is called.

An automatic telephone is a common battery system telephone equipped with a dial. When the dial is spun according to telephone signal, the correspondent is called through the automatic switchboard.

As for types of telephone sets, there are the wall, desk and portable telephones (Fig 37).

Part Three: Telephone Switchboards

At first the telephone was used to communicate between only two places. However, with the subsequent increase in the number of telephone sets, the necessity of communicating freely with any set arose; in other words there grew a need for a telephone exdhange. There are two types of switchboards, namely the manual-switchboard and the automatic-switchboard. The former is operated by a switchboard operator while the latter works by automatic mechanism.

(1) The Manual Switchboard

The manual switchboard is classified as a magneto system or a common battery system. The

(2) The Magneto Switchboard

There are two types of magneto switchboards; the wall model (Fig 38-2) and the desk model (Fig 38-1). The former is used when there are only a few subscribers accommodated, i.e. about 20 to 30. For circuits numbering more than 30, the latter is used. The construction of the magneto switchboard is quite simple, but it is somewhat inconvenient for serving subscribers. Consequently, it is more adopted for a telephone exchange in small towns where the telephone traffic is comparatively light.

Aside from big cities, in police communication also, the magneto switchboard is in most common use. According to the number of accommodated subscriber circuits, the magneto switchboard is divided into

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Aside from big cities, in police communication also, the magneto switchboard is in most common use. According to the number of accommodated subscriber circuits, the magneto switchboard is divided into two types from the standpoint of performance -- the single system switchboard and the multiple system switchboard.

(A) The Magneto Single System Switchboard.

As mentioned earlier, in the magneto system of exchange the transmitting current of subscribers is supplied from the local batteries which are provided in the telephone of each subscriber.

When calling the exchange or when signalling the completion of conversation, the indicator of the exchange is put into motion by using the magneto dynamo attached to the telephone.



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When the magneto switchboard receives a signal from the telephone, the switchboard drop line is pulled out and the telephone operator inserts the answering plug (a metal peg to fit the jack, Fig. 38-37) into the jack of the subscriber corresponding to the indicator that moves and answers (cylinderical opening in the switchboard). The opening is metallic and the inner part has a spring contact surface.

( In the switchboard, it forms the terminal of the telephone circuit. Fig. 38-4)

Next, the operator inserts the calling plug of the connecting cord into the jack of the correspondent and gives a signal (the operator turns the handle of the ringer attached to the switchboard) to call the correspondent and connects the two. When the conversation ends, the ring-off apparatus of the cord circuit is set off by the subscriber and the operator disconnects the connecting cord. A 100 circuit switchboard is equipped with 100 jacks and 100 drop lines necessary to handle the telephones it accommodates.

Moreover, the plug board is equipped with a 12 circuit connecting cord necessary for operation of exchange connection. This connecting cord has one answering plug, one calling plug and a ring-off apparatus and one combined key corresponding to the two plugs. For the operators to carry on conversation, the switchboard is equipped with one telephone circuit,(It consists of transmitter and receiver) used jointly by each connecting cord, and one dynamo for signalling purposes.

Thus, the single system switchboard is equipped with a jack and a drop for each subscriber. Since one jack is used jointly for both incoming and outgoing signals, as the number of switchboards increases, if the operator wishes to connect her switchboard directly with another switchboard other than the adjacent switchboard, she must connect them through the junction line between the switchboards.

(B) The Magneto Multiple System Switchboard

The magneto multiple system switchboard is equipped with an answering jack and a multiple system jack for each subscriber circuit. The multiple system jack has a multiple connection, therefore, every operator is able to use the jack.

Unlike the single system switchboard, it does not have to handle the calls of the junction line, consequently, the operator's efficiency is markedly heightened.

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2. The Common Battery System Switchboard

The operation of the common battery system switchboard is almost the same as that of the magneto system switchboard except that a lamp is used as the indicator.

The subscribers use the common battery system telephone, and the transmitting current is supplied from the joint source of electricity (batteries) which is provided at the exchange office. To call the exchange, one simply has to take the receiver off the telephone.

To send the ring-off signal, one merely replaces the receiver on the telephone.



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The common battery system switchboard is therefore used where the telephone traffic is heavy or where there is a great number of accommodated circuits. (Fig 39). There are also two types of common battery system switchboards; the single system and the parallel mutiple system. The former is used for exchange in small towns where the number of subscribers ranges from 30 to 200 and the latter in large cities with 200 to 8000 subscribers.

(2) The Automatic Switchboard

The automatic switchboard belongs to the common battery system switchboard class. Its working principle is: When the finger plate of the dial on the telephone is dialed according to the telephone number of the correspondent, pulse current is transmitted to the switchboard putting the electro-magnet into action. With each number, the shaft of the switchboard rises and rotates and selects the telephone circuit to be connected. (Fig 40)
The advantages of an automatic switchboard are:

1. It eliminates artificial errors caused by operators.

2. Protects secret of conversations.

3. Maintains constant service to subscribers day and night.

Part Four: Circuits

A circuit serves to carry the sound waves produced by the telephone transmitter to distant places, and consists of electric wires and supports.

As for the kinds of circuits, there are the overhead bare circuit, land cable circuit and submarine cable circuit (Fig 41)

(1) Bare Circuit

By bare circuit is meant bare lines installed on poles. Hard copper wires are generally used, but occasionally from the standpoint of economy and in localities where there are heavy wind and snow storms, iron wires are used. The number of lines installed on one circuit is limited to 24. However, there are a few circuits with only one line, although the minimum is generally two. Two lines form one circuit. Generally, for eight lines or less of small wires, the height of the poles used is over seven meters, for 24 lines or less of medium wires, the poles are over eight meters and for 42 lines of big wires, nine meters.

In short, poles from 7 up to 12 meters are used, but they are

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In short, poles from 7 up to 12 meters are used, but they are slightly smaller than those used to support electric light wires.

The poles are made from cryptomeria or Japanese cypress. When treated with creasote they last three to four times longer than non-treated poles. In the past, practically all of the poles were treated with creasote, but recently this is difficult because of the shortage of creasote.

Cross-arms are used for stringing the electric wires on the poles. The length of the cross-arm ranges from 60 centimeters to 2 meters, 40 centimeters.

Generally, the cross-arm is installed about 20 centimeters from the top of the pole and three is the maximum for four lines or eight lines. The distance between the lines is wider when short cross-arms are used, and narrower in case of long cross-arms.



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The distance varies from 48 centimeters down to 28 centimeters. The regular route length (the sum of the distance between the poles) is used to indicate the length of the circuit, and the line length is indicated by the developed length (the sum of the length of the wires. Bare circuits were widely used in the past, but because in many cases they are affected by the elements or other external conditions and the safety of communication becomes difficult to maintain, bare circuits today are used only in areas where few lines exist or where installation of cable is uneconomical. Expecially, when a number of circuits are installed on one pole, electrical coupling between the circuits frequently occurs and lead to cross-talk. To avoid such a situation, the transposition system is used.

(2) Land Cable Circuit

A cable is made from thin copper wires (called core wire) wrapped spiral-wise in good quality insulated paper which are twisted into pairs and bundled into the needed amount. This is covered with good quality insulated paper to form the core of the cable. The insulated paper is coated with three percent tin or lead containing one percent antimony. This type of cable is generally called lead covered cable. As a rule, soft ordinary single copper wire with a diameter of 0.5, 0.65 or 0.9 millimeters are used as a conductor.

For insulation, good quality paper like manila paper which is uniform in quality and thickness and which does not absorb water is used (Fig 42).

For local circuits, cables with a core of 13, 25, 50 or 100 pairs of wire or in multiples of 100 are commonly used. Recently, enormous cables with a core of 1.200 or 1.800 pairs of wires have been also used. There are two kinds of cable line; overhead cable and underground cable.

Overhead cables are supported by hangers which are attached to the cable support wires strung from pole to pole.

Underground cables are inserted in concrete, earthenware or iron pipes and laid underground to form a pipe line.

Man-holes are constructed at service points and connecting points of the cable and as the name indicates, a man is able to go in and out of these holes freely. As stated earlier, cables have replaced bare wires and are now used widely for circuits. Today, all important circuits between cities are cables, not to mention local circuits.

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(3) Submarine Cable

Communication across oceans is generally transmitted by wireless. However, because large number of wireless communications have given rise to interference and jamming and the situation no longer permits construction of new wireless stations, and moreover because submarine cable protects the contents of communications, the use of submarine cables for communication across oceans is becoming more and more widely used.

As submarine cables are laid on the ocean floor, the cables are wrapped with several layers of insulator and metal in order to protect the wires and are built strongly.



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Part Five: Auxiliary Office Apparatus

Before the line wires are housed in the switchboard, there are such auxiliary facilities as safety applicances, switchboard panels, office cable, testing devices and power units, which are also considered a part of the telephone equipment besides those mentioned above. These apparatus are called auxiliary office installations.

(1) Safety Applicances

Safety applicances are devices which protect lines, buildings, and telephones from such electrical hazards as lightening, entanglement of high voltage wires, etc. A fuse severs the telephone current by melting when the current is too strong. A thermal coil is used against shorted current (?) with magnetic telephones, and the lightening arrester against high voltage current.(Fig 43-1 and 2)

(2) Switchboard Panel

When installing several telephone circuits into an office, it is more practical to arrange the circuits in the numerical order of the line wires, and in the numerical order of the telephone numbers on the switchboard.

However, since the telephone numbers and the line wires do not usually coincide, the switchboard panel is used to connect the two. Fig 44-1 and 2.

(3) Power Units

As mentioned earlier, the telephone is classified as magneto system or common battery system according to whether or not the subscriber has his own source of power. At magneto system exchanges, operators use gravity batteries or air batteries for the purpose of carrying on conversation. At common battery exchanges, 24 volt batteries are usually used, therefore 11 secondary batteries connected in series are used.

A simultaneous charging and discharging process is employed for this, and a motor generator is used for charging. Since a signal dynamo is used for signalling, a motor generator is used.

The power unit for an automatic switchboard is practically the same as that of the common battery switchboard except that 48 volt or 60 volt batteries are used.

Part Six: Carrier Telephone System

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Part Six: Carrier Telephone System

Carrier telephone is a method of communication by which multiplex communication can be conducted on a single line by installing proper equipment at the exchange. To explain in detail, in carrier telephony, telephone circuits are superimposed on electric current with frequency for higher than voice frequency (between 3 and 20 kilo-cycles) and current which modulates the amplitude of the high frequency current wave form of the telephone current is transmitted through the wires and returned to the original current and received.

This system is known as carrier telephony because high frequency is used to carry the telephone current. (It has already been mentioned that high frequency which carries the telephone current is called the carrier). By using several types of carrier waves, it is possible to hold more than one telephone conversation on a single line.



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This is the distinguishing feature of this system (Fig 45 (1) and (2)). In order to make the above possible, the following four elements are vital in carrier telephony.

1. High-frequency current generator.

This apparatus generates carrier current and uses ordinary vacuum tubes. (Will be explained under wireless).

2. Modulator.

This equipment modulates carrier telephones by voice current. It also uses ordinary vacuum tubes.

3. Selectors.

This apparatus is a wave filter which transmits only the modulated current from among the different currents which flow from the modulator, and transmits it to the lines. It also selects the different carrier currents which are sent from the other end and leads them to the proper equipment.

4. Demodulator

A demodulator is an apparatus which restores the modulated carrier current to the original voice current and to the original high frequency current. It too uses ordinary vacuum tubes.

Since the carrier telephony system does not require large line construction and maintenance expenses its strong point lies in its economy.

It does not require enormous outlays as those necessary for laying submarine cables nor is there any need to increase the lines once the circuit is installed. For this reason, almost all of the multiplex circuits between cities employ the carrier telephony system today.

Part Seven: Telephone Relay Equipment.

When telephone lines extend over a great distance, telephone current becomes gradually weaker as it flows thus making reception difficult. To prevent this, telephone relays are installed enroute at appropriate positions to amplify the weakened current being transmitted. In this method, best results are obtained by using ordinary vacuum tubes.

Although there are structural variations depending on whether it is a two line system or a four line system, better ones are capable of transmitting current as far as 8.000 kilometers.

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Part Eight: Simultaneous Address System.

The simultaneous address telephone is a device which, by using the telephone circuit, rings the entire line simultaneously to issue order calls. There are two types: one relies on the carrier method and the other employs low frequency waves after a temporary break is made in the telephone circuit. As mentioned earlier, under the carrier method, multiplex transmission is conducted by means of carrier waves, therefore, even during the course of conversation, order calls can be made without any effect on ordinary telephone traffic.

This apparatus consists of a key to establish a simultaneous circuit, an electric lamp with which the receiver answers, another electric lamp with which the receiver notifies the sender that he is receiving and a sound amplifier.



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This apparatus for simultaneous address is especially useful in police communications and is used widely for hunting down criminals and for sending information (See Fig. 46)

Section Three: Wireless Communication Apparatus

Part One: Telegraph

As with wire communication, wireless communication relies upon either telephone or telegraph. Heretofore, the telephone was chiefly used to explain wire communication, therefore, at this point, a brief explanation will be given on telegraphic communication.

There are various types of telegraphic apparatus. Besides the manual and automatic MORSE code telegraph, facsimile telegraph, printing telegraph, etc. are also now in use.

A. Telegraph by MORESE Code.

From its invention up to the present the hand-operated MORSE code telegraph has been used extensively. Signals are transmitted by cutting electric current intermittently to correspond to the dots and dashes of the MORSE code.

The device to transmit telegraphs consists of a key and power supply (alternating current and batteries for transmission). The receiver consists of a relay, batteries for local circuit and a sounder. When the transmitter and receiver are connected by wire, this is called a wire telegraph and when contact is made between the transmitter and sender without wire, i.e., by radio or electric waves, this is called a radio or wireless telegraph.

Needless to explain, a key (see Fig. 47) is an implement which is tapped with the tip of the finger to interrupt the electric circuit to correspond to the MORSE code. The "Heart" of a sounder is the electro-magnet which, with the flow of electric current, pulls a strip of iron which acts as a pole-contact piece into contact. When the current is cut off, the metal strip is released to its normal position. With each contact of the metal to the electro-magnet, a clicking sound is emitted. The length of the click, that is whether it is short or long, determines whether it corresponds to a dash or dot of the MORSE code. The message is received by distinguishing these dots and dashes (for

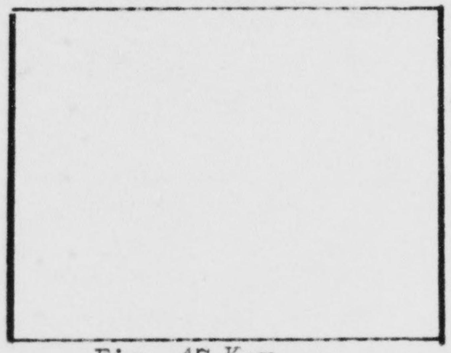

Fig. 47 Key

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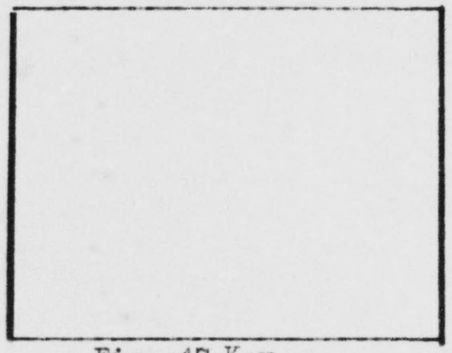

Fig. 47 Key

There are two methods in the sending and receiving of telegraphs, namely, simplex telegraphy and duplex telegraphy. The former, like wireless telegraphy, can transmit messages only one way. For instance, from station A to station B, or vice versa. Under the latter method communication can be sent from both ends simultaneously through a single wire as used in wire telegraphy, without any interference.



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| | | |
|---|---|---|
| A . - | i - | no . . - - |
| B - . . . | ro . - . - | o . - . . . |
| C - . - . | ha - . . . | ku . . . - |
| D - . . | ni - . - . | ya . - |
| E . | ho - . . | ma - . . - |
| F . . - . | he . | ke - . - - |
| G - - . | to . . - . . | fu - - . . |
| H . . . . | chi . . - . | ko - - - - |
| I . . | ri - - . | e - . - - - |
| J . - - - | nu . . . . | te . - . - - |
| K - . - | ru - . - - | a - - . - - |
| L . . - . . | wo . - - - | sa - . - . - |
| M - - | wa - . - | ki - . - . . |
| N - . | ka . - . . | yu - . . - - |
| O - - - | yo - - | me - . . . - |
| P . - - . | ta - . | mi . . - . - |
| Q - - . - | re - - - | shi - - . - . |
| R . - . | so . - - - . | ye . - - . . |
| S . . . | tsu . - - . | hi - - . . - |
| T - | ne - - . . . | mo - . . - . |
| U . . - | na . - . | se . - - - . |
| V . . . - | ra . . . | su - - - . - |
| W . - - | mu - | n . - . - . |
| X - . . - | u . . - | |
| Y - . - - | wi . - . . - | |

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| | | |
|---|---|---|
| J .- - - | nu . . . . | te .- . - - |
| K - . - | ru - . - - | a - - . - - |
| L . - . . | wo . - - - | sa - . - . - |
| M - - | wa - . - | ki - . - . . |
| N - . | ka . - . . | yu - . - - |
| O - - - | yo - - | me - . . . - |
| P . - - . | ta - . | mi . . - . - |
| Q - - . - | re - - - | shi - - . - . |
| R . - . | so . - - - . | ye . - - . . |
| S . . . | tsu . - - . | hi - - . . - |
| T - | ne - - . . . | mo - . . - . |
| U . . - | na . - . | se . - - - . |
| V . . . - | ra . . . | su - - - . - |
| W . - - | mu - | n . - . - . |
| X - . . - | u . . - | |
| Y - . - - | wi . - . . - | |
| Z - - . . | (voiced sound mark) \\ | . . |
| | (Semi-voiced sound mark) o | . . - - |
| 1 . - - - - | 一 . - - - - | |
| 2 . . - - - | 二 . . - - - | |
| 3 . . . - - | 三 . . . - - | |
| 4 . . . . - | 四 . . . . - | |
| 5 . . . . . | 五 . . . . . | |



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| | | | | | |
|---|---|---|---|---|---|
| 6 | . . . . . | 六 | - . . . . | / Dash | . - - - - |
| 7 | - - . . . | 七 | - - . . . | . Period (full stop) | . . . . . |
| 8 | - - - . . | 八 | - - - . . | ㄴ End | . - . . . . |
| 9 | - - - - . | 九 | - - - - . | ⌒ Bracket upper half | - . - - |
| 0 | - - - - - | | 0 - - - - - | ⌣ Bracket lower half | - . - - . |

| | |
|---|---|
| Period (Full stop) | . . . . . |
| Colon | - - - . . . |
| Comma | - . - . - . |
| Semicolon | . - . - . - |
| Interrogation mark | . . - - . . |
| Exclamation mark | - - - - |
| Abbreviation mark | . - - - - |
| Dash - | - . . - |
| Bracket ( ) | - . - - . - |

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| | |
|---|---|
| Comma | - . - . - . |
| Semicolon | . - . - - |
| Interrogation mark | . - - . . |
| Exclamation mark | - - - - |
| Abbreviation mark | . - - - - |
| Dash - | - . . - |
| Bracket ( ) | - . - - . - |



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In the hand-operated MORSE code telegraph, the sounder makes the length of time between each click, but a typewriter, buzzer, headphone, etc. are also used. In wireless telegraphy, since audible alternating current which is interrupted to correspond to the code is used during receiving, the headphone or the loudspeaker produces a whistling sound.

A wireless telegraph key can be operated anywhere oscillation current can be controlled. For instance, electric waves can be sent out from a station in CHIBA Prefecture while the key is operated in TOKYO (In this case, a wire circuit called control line is used between TOKYO and CHIBA). However, according to the type of oscillator used in the transmitter, there are slight variations.

Needless to say, in radio telephone, the telephone or a microphone is used.

B. Automatic Telegraph Apparatus.

An automatic telegraph is provided with a perforator which makes special perforations in tape corresponding to the wording of the telegram. Like a typewriter, the keys of the perforator are either Roman alphabet or KANA, which, when struck, make perforations in the tape corresponding to either the letter of the alphabet or numerals. As perforations are made in the tape, the automatic telegraph sends electric current corresponding to the symbols of the MORSE code at high speed through the wires. An ordinary machine can send about 500 letters per minute.

TWO: Radio Communication Apparatus.

A radio communication set transmits communications by means of electric waves. The set consists of a transmitter which emits electric waves and a receiver which reproduces the content of the correspondence by receiving the electric waves.

A. Transmitting System

The transmitter emits electric waves by generating high frequency alternating current and consists of an antenna, a transmitter and power supply.

1. Antenna

An antenna is an apparatus which radiates electric waves. In order to radiate electric waves, wires are strung high into space as shown in Fig. 49, and a high frequency generator (sender) is connected to the wire leading from the antenna and to one leading from the ground, that is to the wires buried beneath

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B. Automatic Telegraph Apparatus.

An automatic telegraph is provided with a perforator which makes special perforations in tape corresponding to the wording of the telegram. Like a typewriter, the keys of the perforator are either Roman alphabet or KANA, which, when struck, make perforations in the tape corresponding to either the letter of the alphabet or numerals. As perforations are made in the tape, the automatic telegraph sends electric current corresponding to the symbols of the MORSE code at high speed through the wires. An ordinary machine can send about 500 letters per minute.

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There are various types of antenna. To radiate electrid waves effectively, the length, height, shape, etc. of the antenna must be taken into consideration. The most common length of an antenna is generally one half of the wave length. Accordingly, the erection of an antenna with a wave length of several thousand kilometers is quite difficult. On the other hand, an antenna to radiate short waves is quite simple to erect. Furthermore, an antenna for ultra-short waves is practically portable. It is also possible to combine several entennas, and by relying on the reflective quality of electric waves, concentrate the electric waves in one certain direction. This is called a beam antenna (directional antenna).



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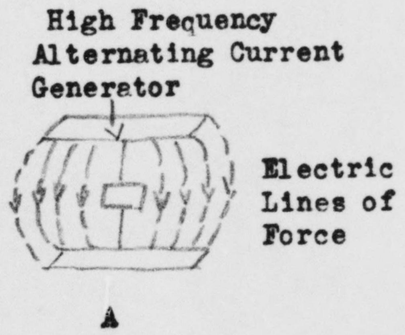
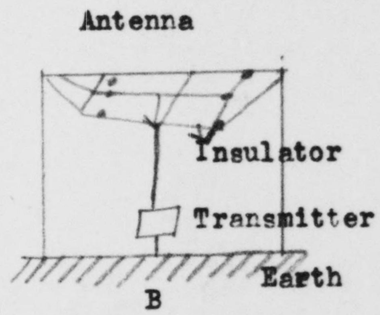
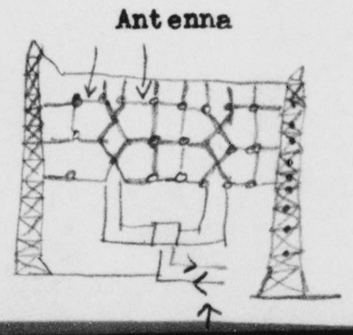


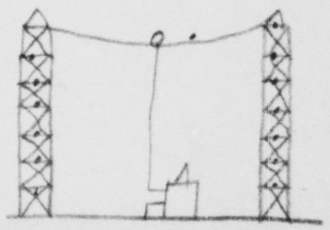

A

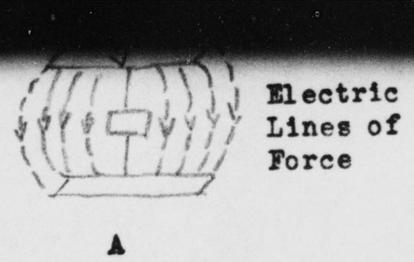



B

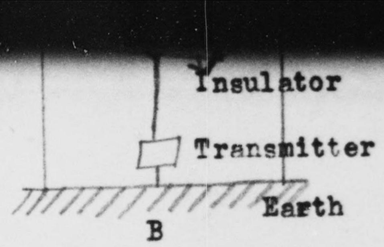
Fig. 49 Transmitting Antenna






A




B

Fig. 49 Transmitting Antenna

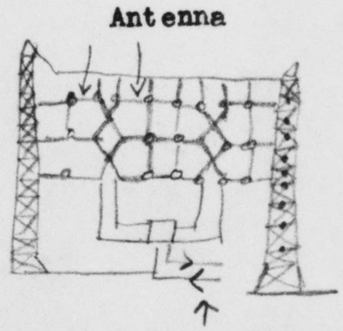



Fig 50 Beam Antenna

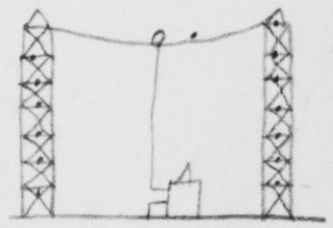


Fig. 51
Transmitting
Vertical AnTenna



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Since the shorter the wave-lengths, the easier they are to concentrate, such electric waves can be used with great effect. Accordingly, in all idstant communications, this beam antenna is used (Fig. 50).

For broadcasting purposes, however, a single vertical antenna as shown in Fig 51 is used, as it is necessary to transmit electric waves uniformly in all directions. Besides the antennas mentioned above, there are various other types to meet different requirements.

2. Transmitters

A transmitter is an apparatus which produces high frequency electric currents and modulates them with telegraphic code or telephone currents or currents of any other wave forms which are to be transmitted. Its construction and types are as follows (Fig 52)

a. Construction

A sender may be divided into two parts, i.e., an oscillator and a modulator.

(1) Oscillator. An ordinary vacuum tube is used to produce high frequency waves. There are three systems, namely, the self-excited system, main oscillation system and crystal control system. The crystal control system is used most widely today. This system produces electric currents of high frequency by combining the crystal oscillator and the vacuum tube, and after amplifying the currents, discharges a homogeneous and continuous flow of electric waves. The advantage of this system lies in the fact that it maintains a uniform oscillation frequency by utilizing the peculiar characteristics of the crystal oscillator. This is made from a slice of quartz cut at a right-angle to the two parallel surfaces of crystalline quartz and which produces a high frequency oscillation voltage of uniform frequency corresponding to the thickness of the said slice when both surfaces are placed under oscillation pressure.

(2) Modulator. A vacuum tube is also used for modulation. As for methods, there are the amplitude modulation method and the frequency modulation method. The latter has been much improved recently, and its outstanding feature is that it reduces static to a minimum. It is especially suited for

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(2) Modulator. A vacuum tube is also used for modulation. As for methods, there are the amplitude modulation method and the frequency modulation method. The latter has been much improved recently, and its outstanding feature is that it reduces static to a minimum. It is especially suited for use in movable stations such as a mobile wireless station.

b. Types

A transmitter is classified into the self-excitation system, main oscillation system and the crystal control system according to the method of oscillation and also into the amplitude modulation system and the frequency modulation system according to the method of modulation. There are also other types such as the wireless telegraph transmitter, wireless telephone transmitter as well as medium wave transmitter, short wave transmitter, ultra-short wave transmitter, etc.



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3. Source of Electricity for Transmitter

In the transmitter, as was explained during the explanation of a vacuum tube, voltage must be applied to the filament, plate and to the grid. There are three kinds of electricity which are used. Direct current or low frequency alternating current is used as the A-source of electricity for the filament. The former is used largely for low power transmitters and the latter for high power transmitters. For direct current, storage batteries or direct current generators are used. Next, as the B-source of electricity for the plate, a high-pressure D.C. generator or a rectifier is used. Since it becomes more difficult for the D.C. generator to generate electricity as the pressure increases, its voltage is usually limited to several thousand volts, and when higher voltage is required, a source of A.C.combined with either a two electrode tube or a hot-cathode mercury vapor rectifier is used. In many cases, a rectifier is used even when the voltage is low. As the C-source of electricity for the third grid, a low capacity battery, D.C. generator or a rectifier is used, since the consumption of electricity is generally very small in the grid circuit of a vacuum tube. Moreover, the electric power of a transmitter is indicated by its output (for example, one kilowatt transmitter, 50 watt transmitter, etc). With telegraphic transmitters, it is customary to compute the output when the key is depressed and with telephone transmitters, the output of the carrier wave when it is not modulating.

B. Receiver

A receiver is a device to catch the electric waves in the air, induce high frequency voltages into the receiver and reproduce them as codes or voices. It consists of an antenna, a receiver and a source of electricity for receiving.

1. Antenna

In order to receive electric waves, an antenna and ground, i.e., a condenser is still necessary. Since the electric waves are a motion of electric lines of force, when they reach the antenna and earth, the results are the same as if the lines of force were produced in the condenser formed by the antenna and earth. Accordingly, a high frequency voltage whose frequency is the same as that of the electric waves is induced.

Usually the receiving antenna need not be as large as the transmitting antenna. In most home radio

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Usually the receiving antenna need not be as large as the transmitting antenna. In most home radio receivers, the antenna is very small. Moreover, in many cases, the light socket is used as an antenna instead. Of course, such an arrangement is adequate to receive powerful waves such as those for radio broadcasting, but to receive ordinary waves an antenna is necessary.

2. Receiver

a. Construction and Principle

A receiver consists of a tuner which selects a certain wave from the electric waves which the reciver has caught with the antenna, a detector which separates the low frequency waves needed from the high frequency waves out of the



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electric waves received, an amplifier which increases the voltage of high frequency waves to be detected and the low frequency waves already detected in order to obtain sufficient volume of sound and a regenerator which regenerates the voice from its low frequency current (Fig 53).

(1) Tuning Circuit. The voltage induced in the antenna contains various electric waves. In order to receive a certain wave, all that is necessary is to equalize the period of electric oscillation of the receiver with that of the wave to be selected and resonance is produced. In other words, when the two drums vibrate for an equal period, an extremely loud sound is produced. Since this utilizes the resonance phenomenon, it is called "tuning".

The turning of the radio dial to receive broadcasts from Station I or Station II (IN: JOAK or JOAB) is the process mentioned above. The loudest sound produced at a certain calibration in the dial indicates that the natural frequency of the receiver exactly coincides with the period of the electric wave.

As for how this tuning is done, a combination of the above explained variable condenser and a coil mounted in the back side of the receiver is used. As already mentioned, since the two charged metal plates of a condenser attract each other and the electricity does not leak easily, (in the long run, however, the electricity does leak, since these two plates are connected by a conductor), the condenser is to constrain the flow of electricity. Therefore, by keeping the coil intact and by changing either the distance of the two metal plates of the condenser or the area of these two plates facing each other, the period of electric oscillation can be changed. Accordingly, in the adjustment of the receiver, the condenser is tuned, and when the dial is turned, a variable codenser which clamps the area of the mutual plates facing each other is used.

b. Detector Circuit

The reception wave obtained from tuning is the alternating current of the high frequency which has been modulated by the low frequency wave, how-

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b. Detector Circuit

The reception wave obtained from tuning is the alternating current of the high frequency which has been modulated by the low frequency wave, however, since its oscillation is so great when connected directly to a receiver or loudspeaker it cannot cause the diaphragm to vibrate. Low frequency is necessary to make the receiver or loudspeaker function and reproduce a voice. The high frequency waves merely turn into electric waves and carry the said low frequency waves. Therefore, a device is needed to extract only the low frequency waves from the reception wave obtained by tuning. This device is called a wave-detector and its function is wave-detecting. Generally, two or 3-pole vacuum tubes, crystal, etc. are used in a wave detector. The wave-detecting process of the vacuum tube is as follows:



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The high frequency voltage obtained from tuning is modulated in various degrees as shown in Fig. 54 according to the voltage of the law frequency current. However, when this voltage is applied to the wave-detector, rectification process takes place, and the electric currents running in one certain direction are stopped and becomes a pulsating current (alternating current added to direct current) as shown in II of Fig 54. When this pulsating current is transmitted through a receiver, the diaphragm vibrates as shown in III and the slund-wave that is generated by the vibration of the diaphragm reaches our ears in the manner shown in IV.

c. Amplifier Circuit

When the high frequency current applied to the wave-detector is less than a certain amount, the sensitivity of the detector becomes suddenly feeble. Therefore, when the current is weak and sufficient volume cannot be obtained by detecting the high frequency voltage secured from direct tuning.

The said voltage has to be amplified. In other words, the amplification of the electric oscillation is necessary. This amplification process is called frequency amplification. Furthermore, when the modulated voltage of the low frequency obtained from detecting is so low that sufficinet volume cannot be obtained even with the aid of receiving apparatus such as receivers, etc., the low frequency voltage must be amplified to the proper degree. This is called audiofrequency amplification. The above amplification processes are all conducted with a vacuum tubes of three or more poles.

d. A receiving set is an apparatus that makes the diaphragm of a receiver or loudspeaker vibrate or puts the recorder into motion with low frequency current to reproduce sound. This process enables us to receive sound.

B. Types

There are various kinds of receivers and according to the types of received waves, they can be classified into A-1 electric wave receiver, A-2 electric wave receiver, A-3 electric wave receiver and A-4 electric wave receiver. Also, according to

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There are various kinds of receivers and according to the types of received waves, they can be classified into A-1 electric wave receiver, A-2 electric wave receiver, A-3 electric wave receiver and A-4 electric wave receiver. Also, according to the types of circuit, the receivers can be further classified into the straight type, regeneration type, super-regeneration type, autodyne type and into the super-hetrodyne-type, etc.

In the straight type the structure of the receiving circuit is as follows:

High Frequency Amplification -> Wave Detecting--> Low Frequency Amplification. It is quite simple. In the regeneration type a part of the plate-circuit of the wave-detector is connected to the tuning circuit which as a result induces high frequency in the tuning coil. This voltage enters the grid of the vacuum tube and undergoes wave detecting and amplification and is sent to the plate-circuit.



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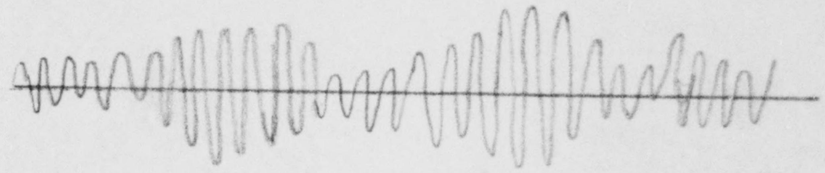
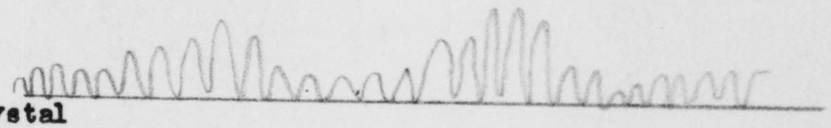
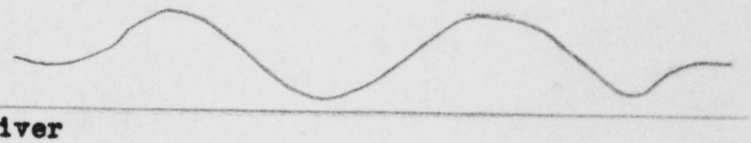
I Voltage af the edge of the tuning coil



$I^1$ Electric current running through a crystal



III Trace of the moving of diaphragm of the receiver



IV Sound wave

Fig 54

WAVE-DETECTING FUNCTION OF CRYSTAL

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running through a crystal

III Trace of the moving of diaphragm of the receiver

IV Sound wave

Fig 54

WAVE-DETECTING FUNCTION OF CRYSTAL

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