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DESIGN AND
CONSTRUCTION
OF THE TELOMAT
THESIS FOR THE DEGREE OF M. S.
Warren Herbert Bliss
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Electric Controllers
Title: Telomat

DESIGN AND CONSTRUCTION

OF THE TELCMAT

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THESIS

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DESIGN AND CONSTRUCTION OF THE TELONAT

Historical

In one respect the degree of civilization of a people may be measured by their ability to (directly or indirectly) control power supplied by nature. The first stages of power control were probably when men trained animals to work for them and used rivers for irrigation. As time went on the values of fire and explosives were learned. Gradually man discovered more and more physical laws and so was able to devise systems whereby the motion of a lever or the touch of a button performed a task which previously had required a great deal of effort. Today we have arrived at such a stage in scientific research that a mere whisper or the passing of a shadow may be made to control an enormous quantity of energy.

By means of a microphone connected to a vacuum tube amplifier system and relays it is possible to open the throttle of a 50,000 horsepower turbine by a single spoken word or sound. This is an example of controlling power by sound energy. Likewise by use of a photo-electric cell it is not at all difficult to control any given amount of power by light energy. These devices can be made so sensitive that a very small change in the sound or light intensity will actuate them.

Because it is advantageous to have one man supervise

many machines or systems and because these systems may be large it was by necessity that remote control methods were invented and brought into use. Today there are many kinds of remote control systems found in practice. The fundamental function of them all is to transmit or communicate a small amount of energy to be used in controlling a larger quantity of energy. As an example of this there are within the United States many powerful radio broadcasting stations which have their transmitters located several miles from the studios and control panels. Also it is quite common practice nowadays to have a person of fame start new installations, unveil statues, etc., simply by pressing a button or by speaking a word in his own home or office.

Requirements of Remote Control Systems

Among the requirements of remote control systems for most types of installations are the following:

1. Instantaneous control of a number of circuits over a single circuit. This means that some type of selection must be had which does not involve the time element. Thus, it might be necessary to operate an oil switch at a distant station at a certain instant or without any delay. It is also an advantage to have a single line or circuit serve as medium for controlling many circuits.

2. Reliability. Some remote control systems are too complicated to be dependable. A good system must be reliable - even more reliable than a man; otherwise it might not

be of advantage to use a remote control device. In controlling an automobile or aeroplane by radio it is essential that the operator be able to depend upon the mechanism of control.

3. Return Signals. Remote control is usually of little use unless the operator has some means of knowing that the distant circuit is functioning according to his desires or commands. This requires that the control mechanism transmit signals or other information back to the sending point so as to tell of its behavior. This is called supervisory control and is used in the remote control of substations or pumping stations.

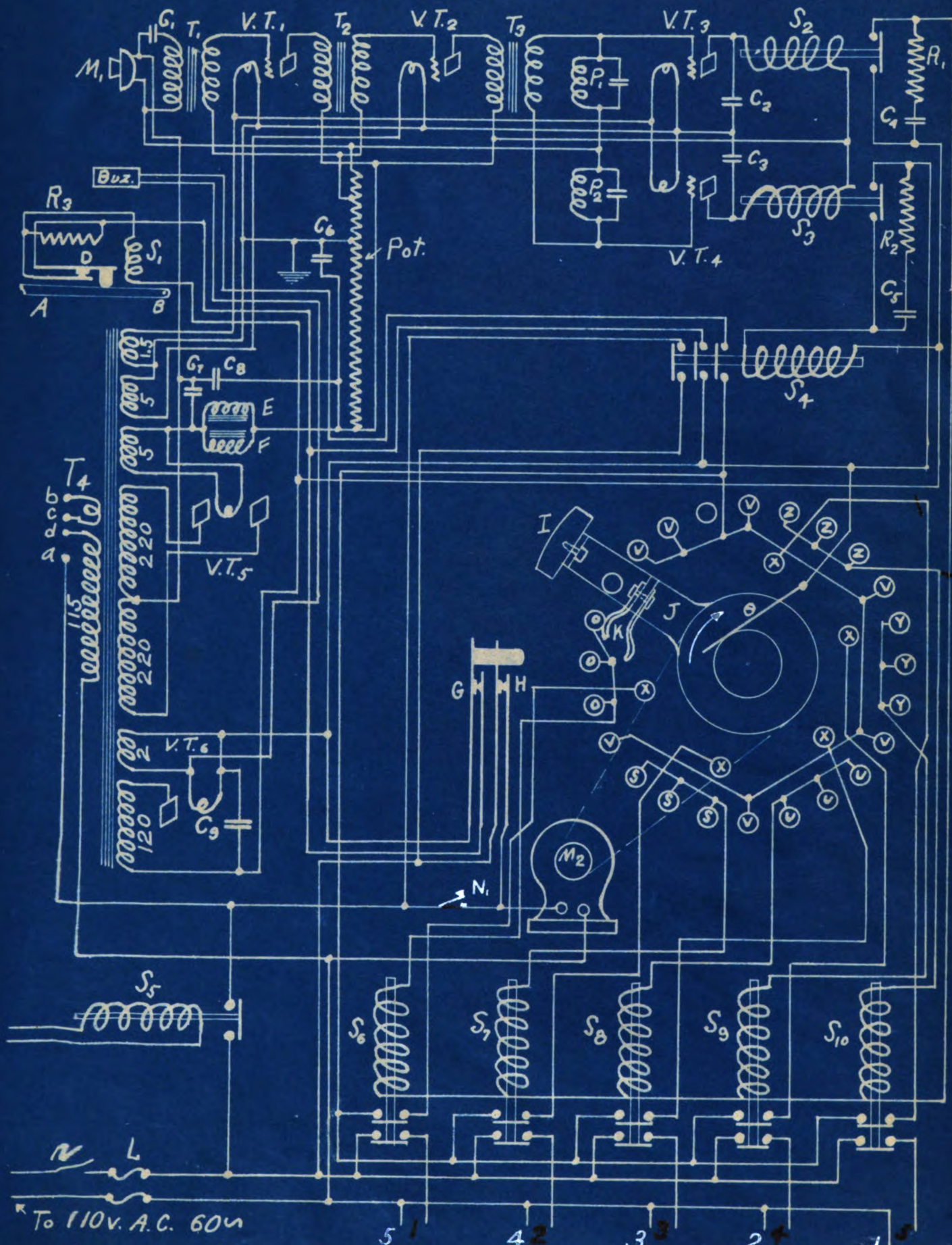
4. Simplicity. Usually the reliability and ease of operation depend upon the simplicity of the system. It stands to reason that if there are fewer mechanical moving parts and fewer electrical circuits the device will be less liable to get out of order. It is undoubtedly best that the manipulation of the system should be so simple that a technical expert is not required to operate it.

Characteristics of the Telomat

When the Telomat was designed it was desired to build a device which could be operated over any telephone line now in service, which would have a minimum of electrical connections to the line and would have provision for controlling five circuits. These three characteristics in addition to those discussed below were incorporated in the design.

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Connection Diagram of the TELOMAT



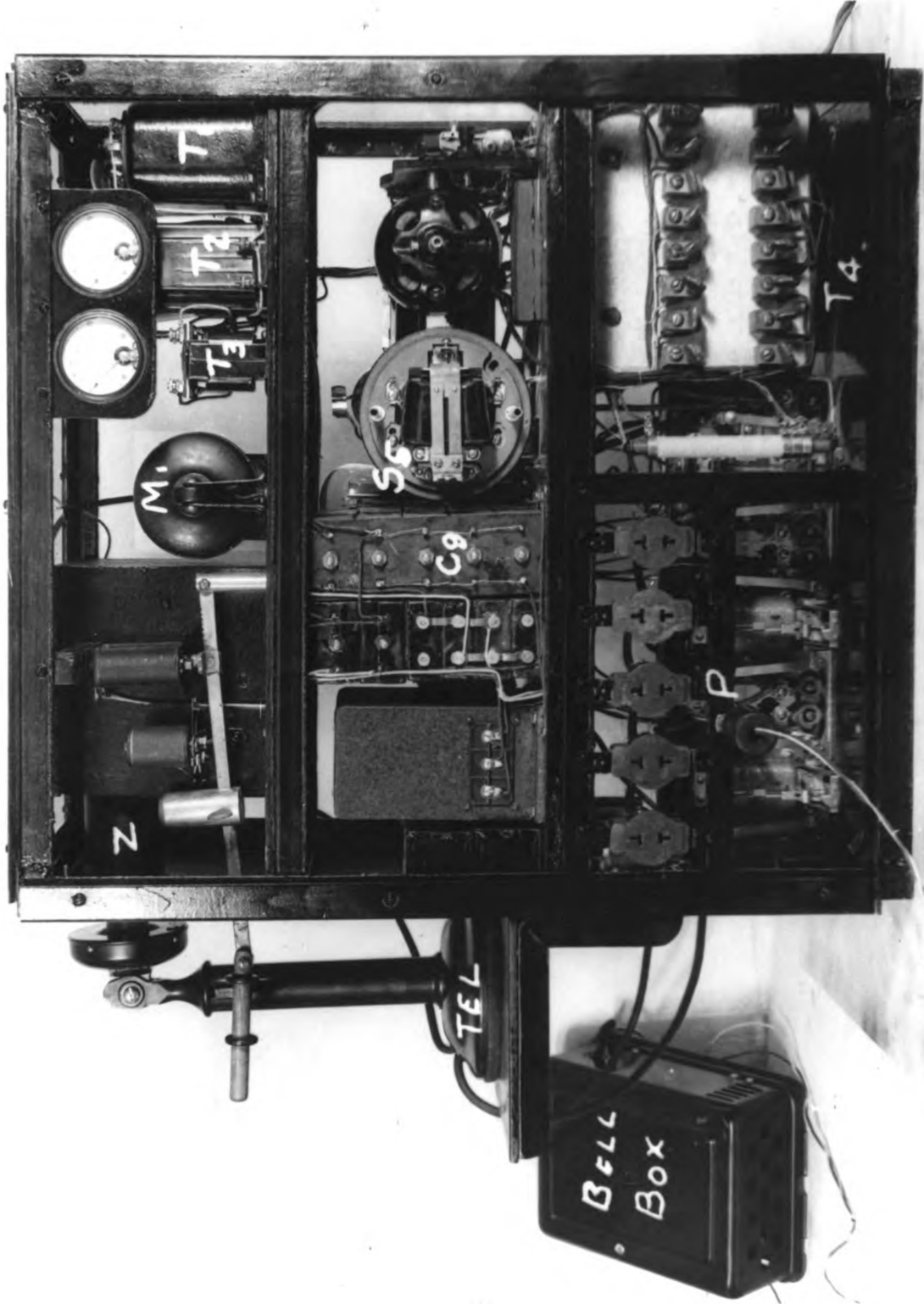


Photo A Front View

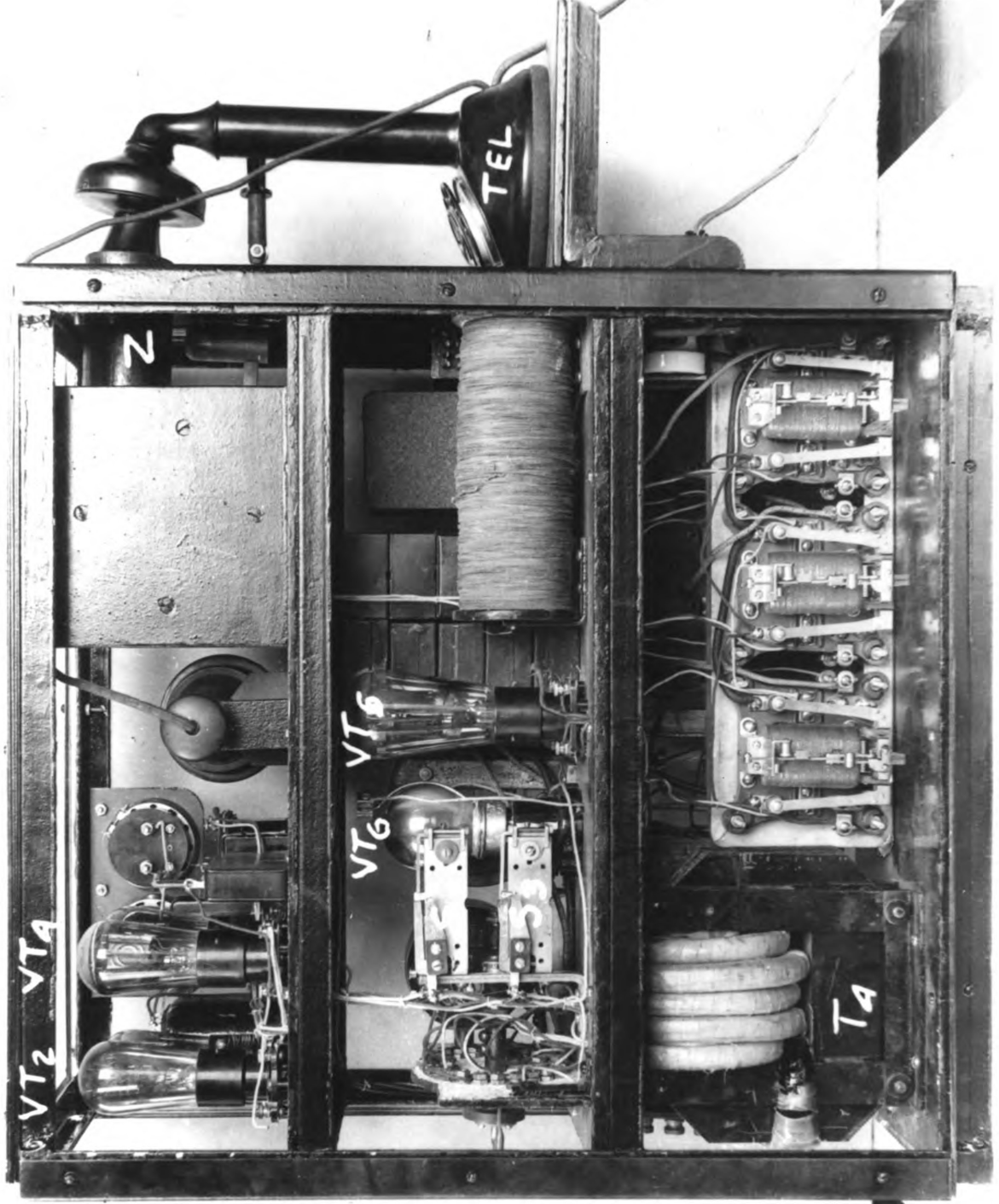


Photo B Rear View

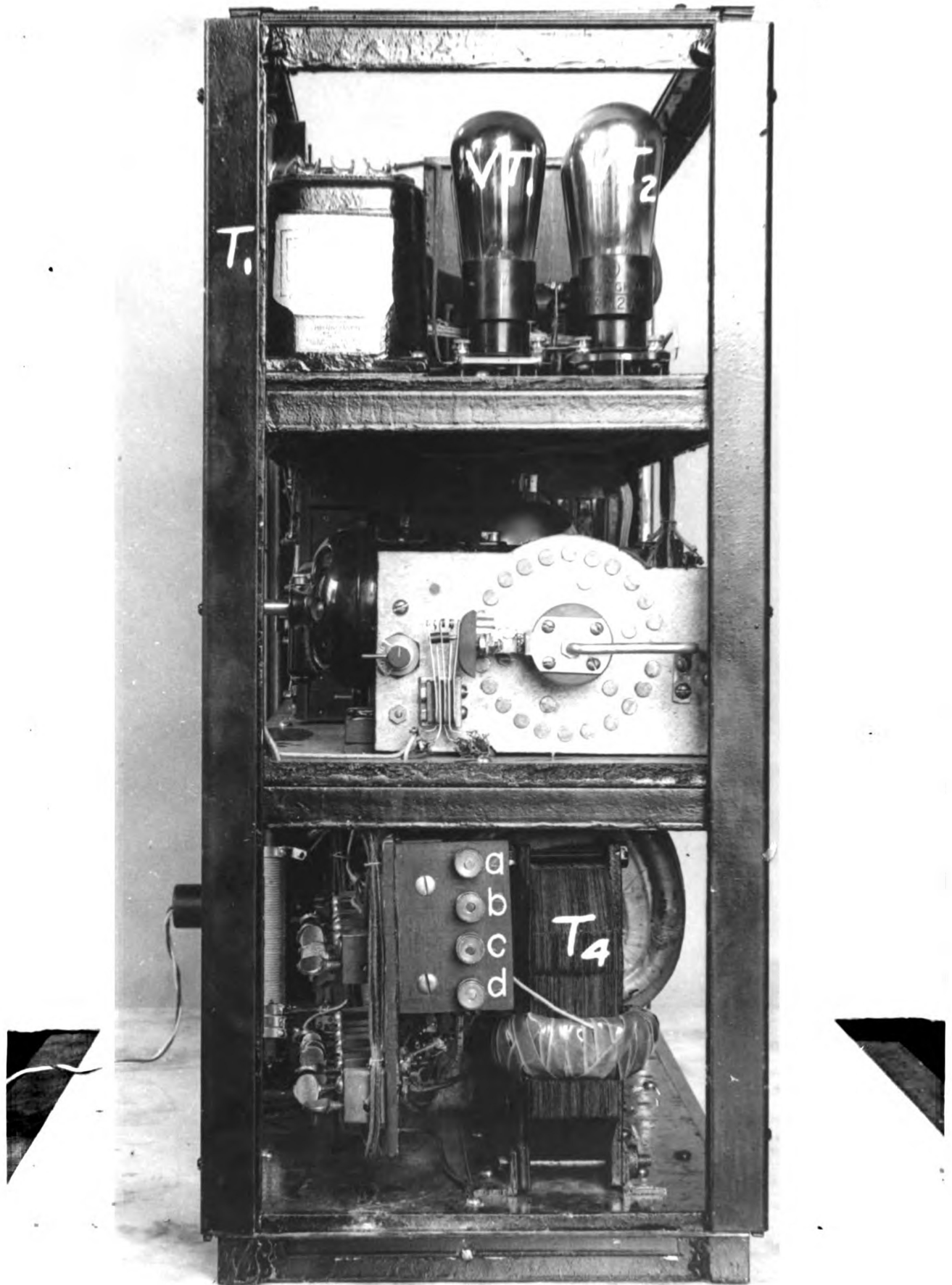


Photo C

Right End View



PHOTO D

Top View

The Telomat is not difficult to operate. Two tones or whistle notes are required and by using these notes at the proper instant as determined by the buzzer signals sent back by the device, any of the five circuits may be opened or closed.

Supervisory control is also used. By means of the system of buzzer signals employed it is very easy to tell which of the five circuits are open and which are closed.

Another feature is that the answering of the telephone is carried out in a very natural manner. The receiver lies in a certain position within the glass case of the Telomat and the transmitter is directed into a rubber tube connected to the buzzer chamber. The receiver hook is lifted when a call is made and lowered when the call is completed. The device responds or starts "listening" when the bell rings and in case no message is sent it "listens" for ten seconds and then "hangs up".

General Construction of the Telomat

By referring to the accompanying photos an idea of the general arrangement of the Telomat can be obtained. The overall dimensions are 22 inches high, 27 inches long, and 10 inches from front to back. The parts are assembled on three levels or decks, the heaviest parts being placed on the lower and the lightest on the upper. The frame is made of $\frac{3}{4}$ inch galvanized angle iron with all the joints arc welded. The deck floors are $\frac{1}{2}$ inch slabs of transite. The

entire frame is housed in 3/16 inch plate glass except for the end on which the phone shelf is mounted. The metal framework is painted black.

The general layout of parts is as follows:

Bottom Deck

Notation on
Connection Diagram
T₄

1. Power Transformer
2. Alternate Impulse Locking Relays S₄, S₆, S₇, S₈, S₉, S₁₀
3. "B" Voltage Potential Divider Pot.
4. Plug-in Sockets for the 5 Controlled

Circuits

Middle Deck

1. Contactor Driving Motor M₂
2. Contactor Arm and Mechanism J
3. Telecode Relay S₅
4. Plate Circuit Relays S₂ & S₃
5. Condenser Bank for Tungar Tube C₉
6. Condenser Bank for Plate Supply Filter C₆, C₇, C₈
7. Double Choke for Plate Supply Filter E & F
8. Condensers for Contacts of S₂ & S₃ C₄ & C₅
9. Tungar Tube and Mounting VT₆
10. Type 280 Rectifier Tube and Mounting VT₅
11. Coils and Condenser for Anti-Resonance

Circuits

P₁ & P₂

Top Deck

1. Amplifier Tubes Types 226 & 112 VT₁ & VT₂
2. Response Tubes Types 223 VT₃ & VT₄
3. Audio Transformers T₂ & T₃

- 4. Input Transformer T₁
- 5. Input Microphone M₁
- 6. Holder for Telephone Receiver
- 7. Bypass Condensers C₂ & C₃
- 8. Buzzer Chamber
- 9. Mechanism for Lifting Receiver Hook
- 10. Milliammeters connected in the Plate Circuits of
VT₃ & VT₄ (not shown on the connection diagram.)

Operation of the Telomat in Detail

To understand the following explanation it will be necessary to refer to the connection diagram and to several of the photos.

The power can be supplied by any 60 cycle a.c. circuit of 105 to 135 volts. When the Telomat is called the telecode relay S₅, which is actuated through the plug P connected to the ringer terminals of the telephone, responds by closing its contacts and power is supplied to the power transformer T₄ and the contact driving motor M₂. Before the ringing has stopped the contactor arm J has rotated far enough to allow contacts H and G to close. Since the contacts H are in parallel with the contacts of the telecode relay the motor and transformer continue to be excited until the rotating contactor arm makes one revolution when H and G will be opened again, shutting off the power.

As long as contacts G are closed energy is being supplied to the receiver hook lifting mechanism (see photo H

and parts A, D, R₃, and S₁ of the connection diagram) and the hook is held in the listening position.

To "lock the Telomat in" so that it will continue to listen for more than one cycle or revolution of the arm a "low note" of about 1200 cycles per second must be sent to the machine. This will be picked up by the microphone M₁ shown in photos A and D. By studying the connection diagram it is seen that the microphone is coupled into a two stage audio amplifier circuit composed of vacuum tubes VT₁ and VT₂ and transformers T₁, T₂ and T₃.

It may be pointed out here that the direct current for operating the microphone is supplied by connecting the latter in series with the direct current plate supply from the type 280 rectifier tube VT₅; hence, no battery is needed.

The output of the transformer T₃ goes to the two anti-resonant circuits P₁ and P₂. The latter, which is composed of a capacitance connected in parallel with an air-cored inductance coil, responds to a frequency of 1200 cycles per second. Consequently when this particular wave is applied to the circuit the voltage across its terminals will increase and hence put an a.c. potential on the grid of VT₄. This vacuum tube, type 226, has about -20 volts d.c. normal grid bias and so its plate current is suppressed until the grid is supplied with an a.c. or a positive d.c. voltage.

The a.c. voltage impressed on the grid from the anti-resonance of P₂ will cause an increase in the plate current which flows through the relay S₃. A 0.5 mf. condenser is

connected in parallel with this relay in order to bypass the a.c. and improve the operation. The contacts of the relay are adjusted to close with a change of current of about three milliamperes.

The closing of the contacts of S_3 complete the energizing circuit of the alternate impulse locking relay S_4 which now closes its three sets of contacts. The set of contacts at the left end of this relay (see diagram) is also in parallel with contacts H and the contacts of the telecode relay; consequently with the locking in of relay S_4 power will be supplied continuously to the machine until the low note is again sent to lock out S_4 and the contactor arm comes to the starting and stopping position as shown in photo E.

The right hand set of contacts on S_4 completes the circuit for the buzzer signals. As can be seen from the connection diagram the buzzer circuit will be closed whenever the outer brush K of the contactor arm J makes connection with one of the contacts marked V. Since this brush is long enough to touch two adjacent contacts simultaneously there will be a long buzz as the brush passes over the two consecutive contacts VV at the upper left position and short buzzes as it passes over each of the other V contacts spaced uniformly around the circle. For one revolution of the arm these signals would be as represented in the following graph:

<u>long</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
10 seconds					

The buzzer signals are picked up by the transmitter of the telephone and so the distant operator can tell the exact position of the contactor arm at any particular instant by listening to the signals and noting the number of short impulses following the long impulse. If he hears only the hum of the mechanism but no signals he knows that relay S_4 is open.

Suppose the operator has the machine "listening" and sending buzzer signals and he wishes to close in one of the control circuits, say circuit No. 2. This requires that relay S_9 be operated. By tracing the connections it will be seen that this can be done by the closing of S_2 when the contactor arm is in such a position that the outer brush K is in connection with one of the contacts YY. To carry out this function the caller listens for the second short signal after the long one and then whistles or produces the "high note" of approximately 1600 cycles per second. This actuates VT_3 since P_1 goes into anti-resonance and so S_9 , being an alternate impulse locking relay, is locked in by the action of S_2 .

The right hand contacts of S_9 cause circuit No. 2 to be energized and the left hand contacts complete another signal circuit connected to contacts XX so that as the arm passes this same point the next time around, two short buzzer signals will be heard instead of one. If circuit No. 4 were also closed the system of signals for one cycle or revolution of the arm would be

Long 1 2 - 3 4 - 5

10 seconds

In other words two short impulses instead of one are heard for the particular circuits which are closed.

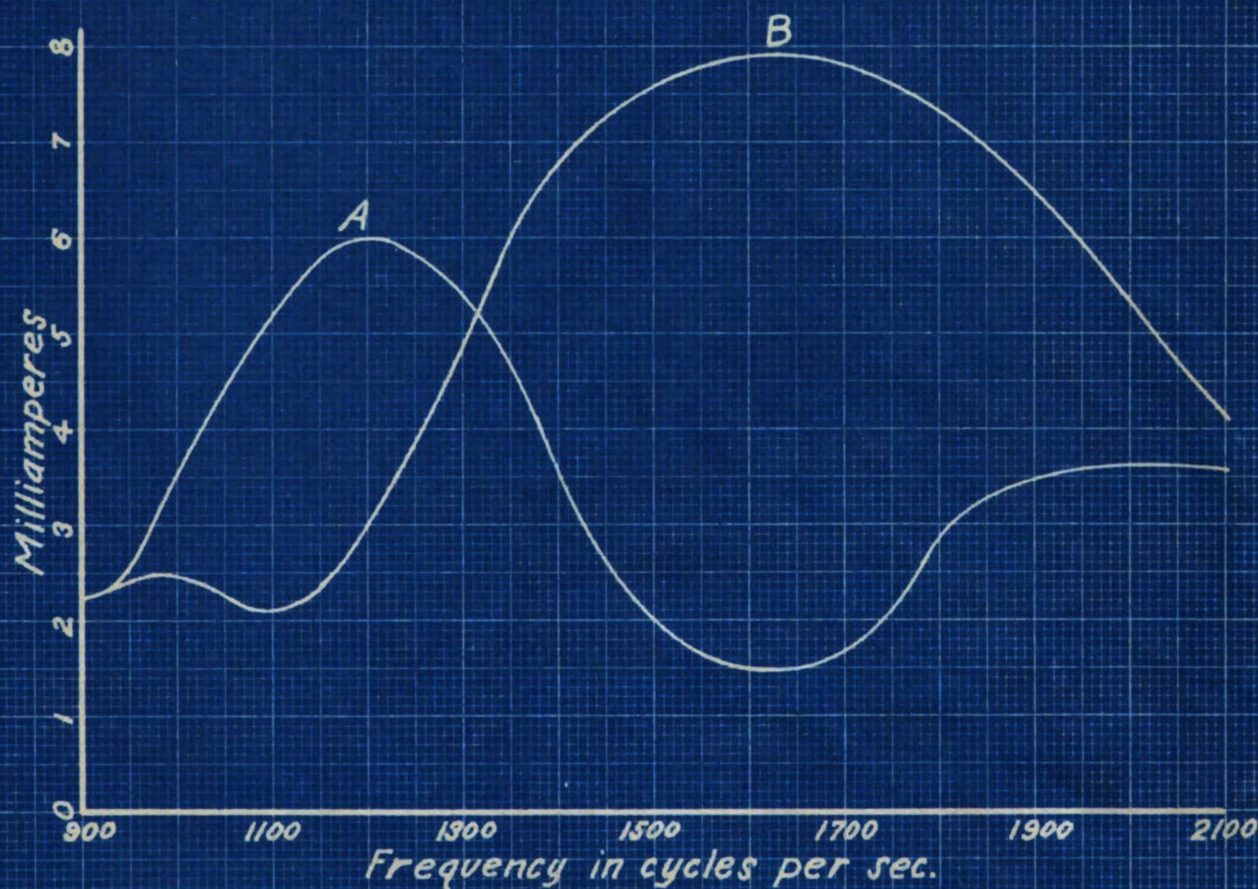
The Telomat has now been "called up" and is "listening", circuits 2 and 4 have been closed in, and the operator has heard the return signals so he says "Goodbye" by whistling the low note again. This locks out alternate impulse relay S₄ and the machine shuts itself off when the contactor arm comes to the stopping position. Of course, the two control circuits are still closed in and energized.

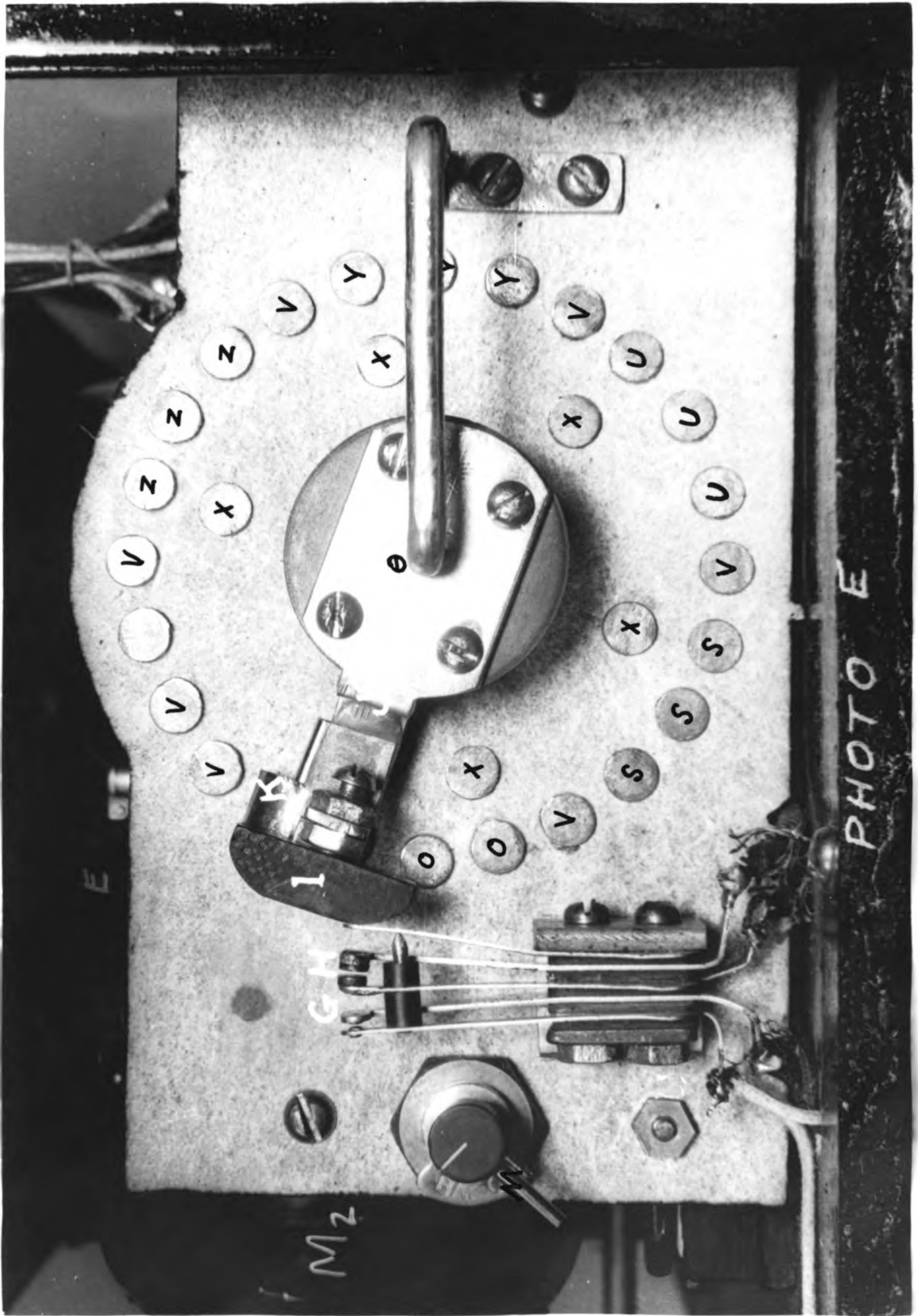
Circuit No. 2 can be opened by calling up the Telomat, whistling the low note to lock in, and then whistling the high note at position 2 of the contactor arm as indicated by the buzzer signals. After this is completed the low note is again sounded to say "Goodbye". In a similar manner any of the 5 circuits may be opened or closed.

Frequency - Response Characteristics

The accompanying graph shows the behavior of the plate currents in the response tubes (VT₃ and VT₄) for a variation of frequency from 900 cycles per second to 2100 cycles per second. Curve A is for circuit P₂ and VT₄ and has its peak at 1200 cycles per second - the low note; curve B is for the other circuit and has its peak at 1600 cycles per second - the high note. Both curves have broad peaks probably due to the resistance of the coils in the anti-resonant circuits. This is convenient since it makes the manipulation of the

Frequency - Response Curves of the Telomat





Contactor Arm and Mechanism

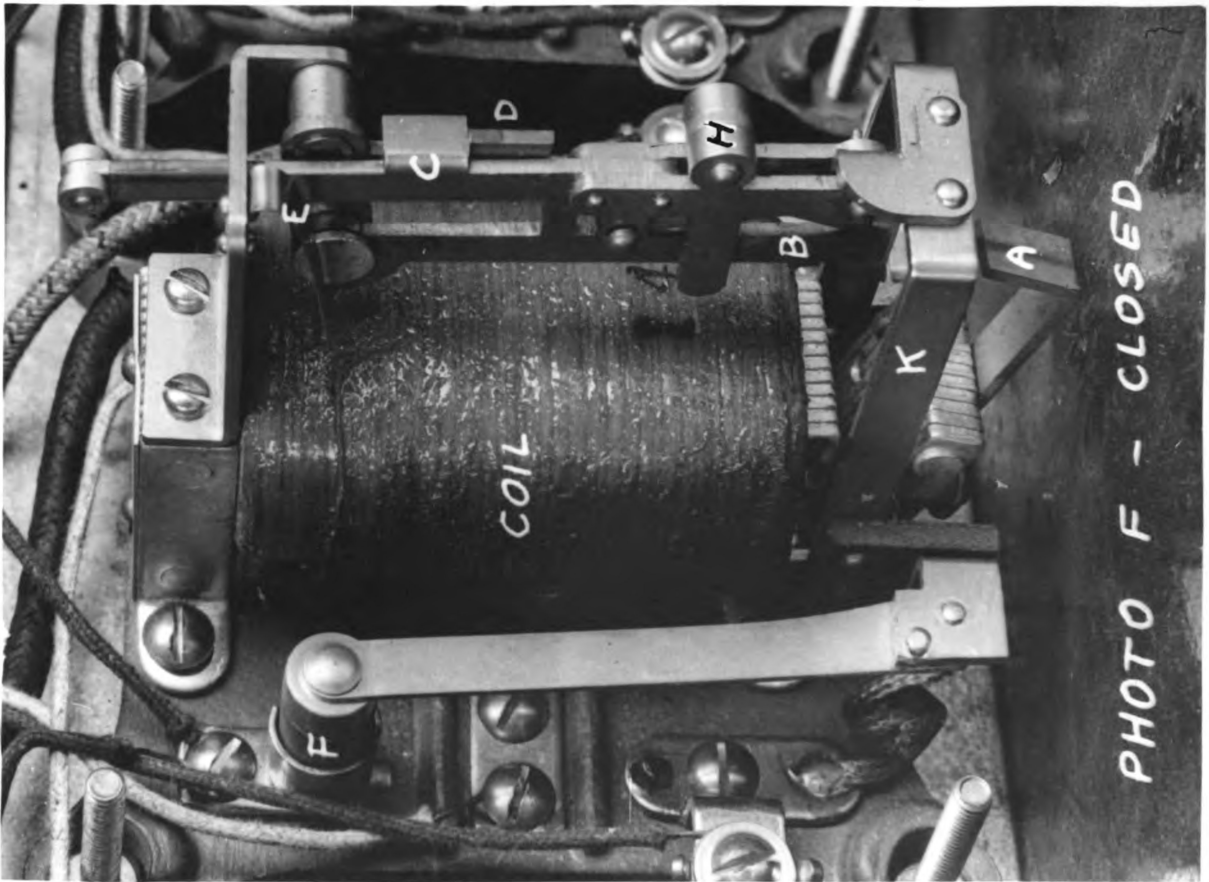
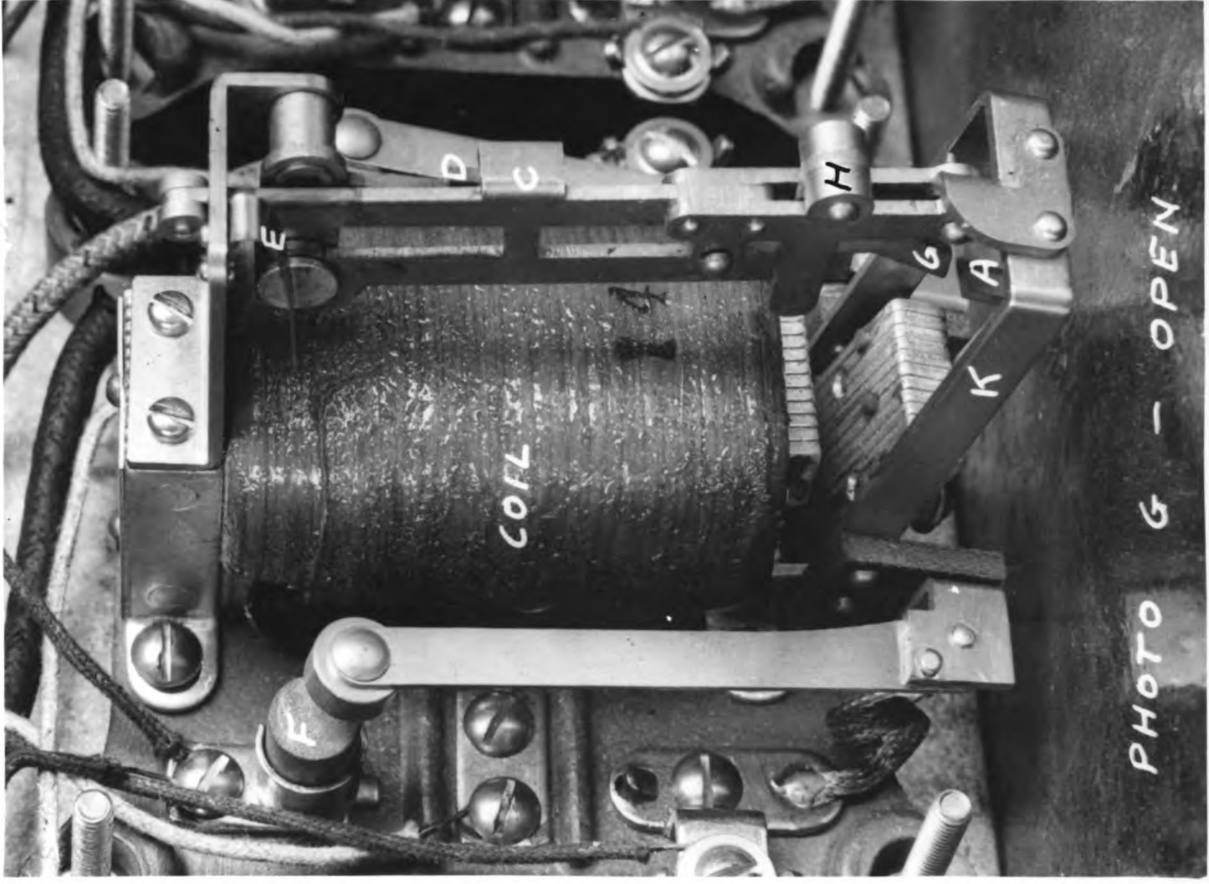
machine easier. That is, it is not necessary to produce a note of exactly 1200 or 1600 cycles in order to get a response. Relay S_2 would undoubtedly close for any frequency between 1100 and 1300 and relay S_3 , between 1300 and 1900.

The curves were obtained by connecting the line of the telephone to a variable audio frequency oscillator of the vacuum tube type. By use of a vacuum tube voltmeter a constant a.c. voltage of variable frequency was applied and the readings of the milliammeters (in the plate circuits) taken. It was noted that once a circuit was in anti-resonance it had a tendency to stay in that condition. Also the response in milliamperes is not proportional to the applied voltage or whistle note. In a laboratory setup using a two subset telephone system the Telomat operated as well over 16 mi. of artificial cable as over a few feet. One reason why the two curves are not similar is the fact that the natural period of vibration of the microphone diaphragm is within this range.

Contact Driving Motor and Mechanism

The driving motor M_2 is a 1/8 HP., 60 cycle, 110 volt, single phase induction motor and operates at about 1750 R.P.M. It has a double worm reduction gear with a ratio of 289 to 1. Hence, the speed of the contactor arm is about 6 R.P.M.

As shown on the connection diagram and by photo E the inner brush K connects with the contacts XX which give the signal when a circuit is closed. The brush Θ completes the circuits to the stationary part of the device.



Alternate Impulse Locking Relay

On the end of the rotating arm is a cam of insulating material which operates the two sets of contacts G and H. Contacts H are heavy as they have to carry the motor and power transformer primary current when S_4 is open. The function of the contacts G will be explained later. The stopping and starting position of the arm is as shown in the photo — when the contacts G and H are open.

The Alternate Impulse Locking Relays

One of the alternate impulse locking relays is shown in detail in photos F and G. The unique feature of these relays is that as the coil is intermittently energized the relay alternately opens and closes its contacts. Hence, one circuit may be made to control both the operations of opening and closing a circuit.

These relays are designed to operate on 55 to 60 volts d.c. and in the Telomat they receive their energy from the Tungar rectifier tube. Their contacts are sufficient for 5 amperes.

Photo F shows one of the relays closed. When the coil is next energized the armature A rises and strikes trigger B which unlatches D from C. This allows part C and arm K to drop down so that the contacts F (the other set of contacts cannot be seen in this view) are opened. As the coil is de-energized the armature drops back down and the relay is as seen in photo G.

When the coil is again energized the armature strikes

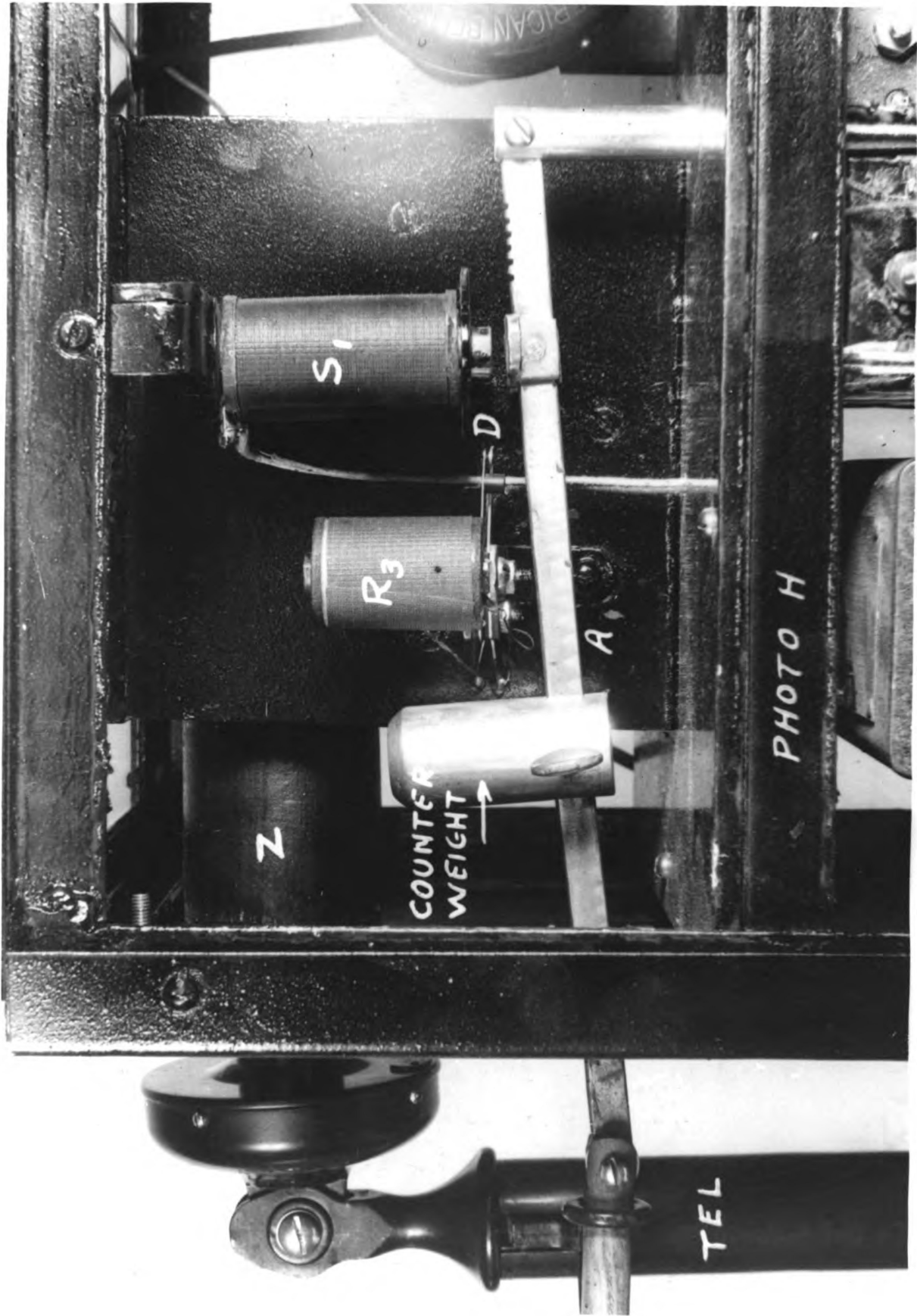
trigger G which has been brought into position by the action of weight W. This lifts arm K and part C is latched back over D, the contacts F being closed again.

These alternate impulse locking relays were manufactured by the Signal Engineering and Manufacturing Company. They are so designed that the action of opening or closing the contacts takes place at the instant when the coil is energized rather than when it is de-energized.

Receiver Hook Lifting Mechanism

Photo H shows how the receiver hook is manipulated by the Telomat and reference to the upper left portion of the connection diagram shows the details of the electrical connections. The counter-weight is adjustable along the lifting arm A to make the mechanism suitable for different tensions of receiver hook springs which occur in various telephones.

All the lifting and holding is done by the electromagnet S_1 . Unfortunately the voltage regulation of the Tungar tube is so poor that if S_1 is left connected during the operation of the Telomat the d.c. voltage is too low for reliably operating the alternate impulse relays. Also it does not require as much current in the coil S_1 to hold the arm up as it does to pull it up. Therefore it was necessary to arrange contacts D to reduce this initial current after the hook was raised by connecting a resistance of 1000 ohms (R_3) in series with S_1 . Hence the "holding" magnetizing force is many times less than the "pulling" force.



Receiver Hook Lifting Mechanism

Power Transformer and Rectifier Units

The power transformer T_4 can be seen in photos A, B, and C. The primary of the transformer is wound for 115 volts, 60 cycles. There are six secondary windings described below in order from top to bottom as shown on the connection diagram:

1. 1.5 volt filament winding for VT_1 , VT_3 , and VT_4 which are type 226 radio tubes.
2. 5 volt filament winding for VT_2 which is a type 112-A tube.
3. 5 volt filament winding for VT_5 which is a type 280 full wave rectifier tube.
4. 440 volt, center tapped winding to supply a.c. to the plates of the 280 tube for rectification.
5. 2 volt filament winding for VT_6 which is a standard 2 ampere Tungar rectifier tube.
6. 130 volt winding to supply a.c. to the plate of the Tungar tube for half-wave rectification.

The transformer has a core cross-section of 3 square inches and the windings have approximately 3.5 turns per volt. All of the terminals except a, b, c, and d are brought out on a terminal block as shown in photo A.

The d.c. plate potential of 150 volts and the d.c. current for the microphone M_1 are supplied by the 280 type full-wave rectifier tube VT_5 . The output of this unit is filtered by the condensers C_6 , C_7 , and C_8 and the double choke E F. A 10,000 ohm potentiometer (Pot.) is connected

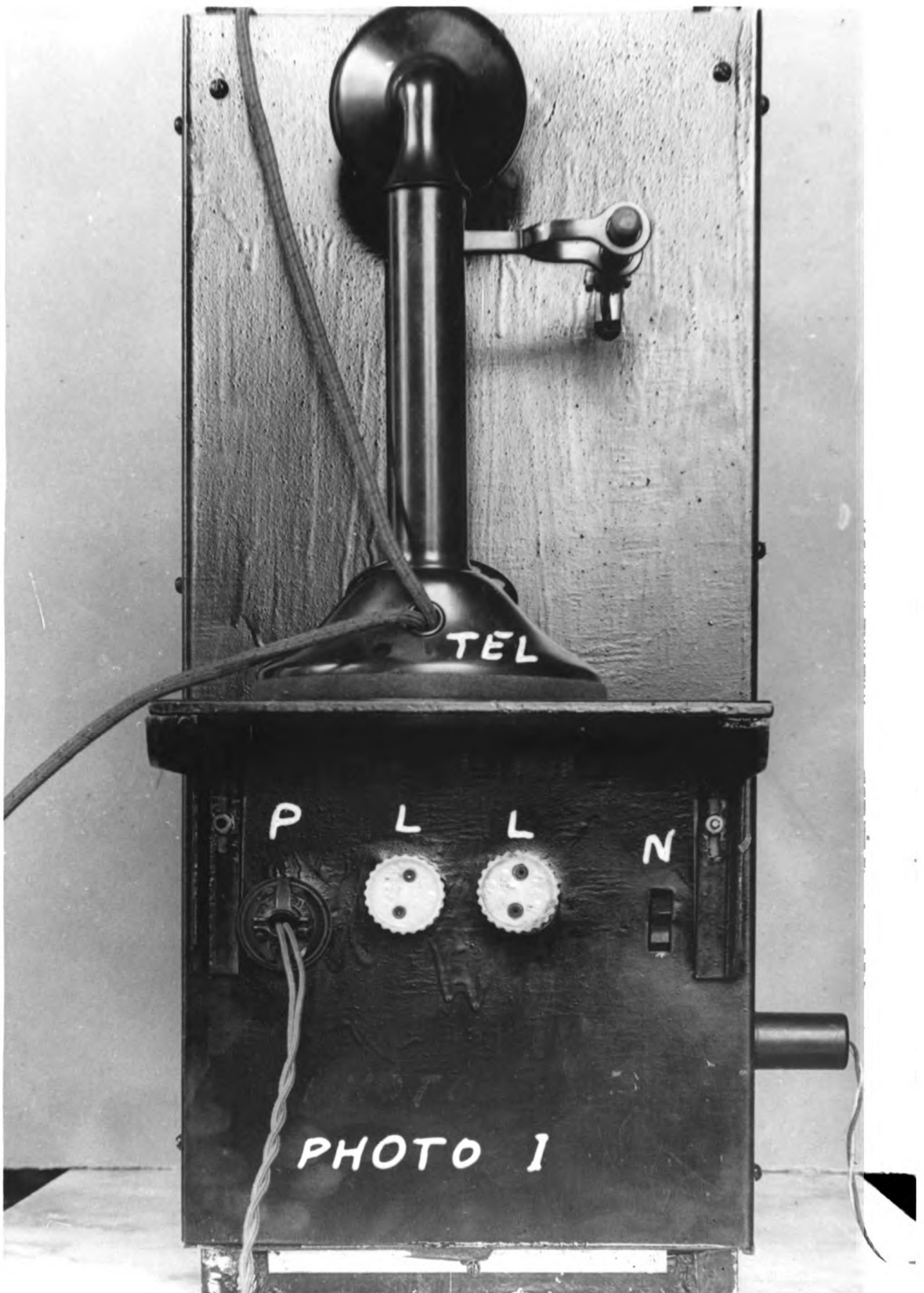
across this supply which serves as a means of obtaining negative potential for the grids of the amplifier and response tubes. The former have -8 volts and the latter -20 volts.

The energy for operating the alternate impulse relays and the receiver hook lifting mechanism is supplied by the Tungar rectifier unit. It is not necessary to have pure d.c. for this purpose and a half-wave rectifier, with only a large condenser for a filter, functions satisfactorily. As mentioned before, the voltage regulation of this device is very poor due to the internal impedance of the tube. Whenever one of the impulse relays is operated this d.c. voltage drops from 150 to 55 volts.

Functions and Facts of Other Parts

Across the contacts of relays S_2 and S_3 are condensers and resistances. Ordinarily a condenser alone is sufficient to stop arcing; however, these relays have to operate on a very small quantity of energy and so there is not much force available to open or close the contacts. With a condenser only there is a sudden rush of current through the contacts when they are first closed due to the discharging of the condenser. This causes the contacts to weld and stick together. The difficulty was overcome by using a resistance of several hundred ohms in series with the condenser.

The condenser C_1 in the upper left hand corner of the connection diagram is used to keep the d.c. out of the primary of the input transformer T_1 . There is only about 40 milliamperes available from the 280 tube and all of this



Left End View

is needed for the microphone.

It was found necessary to keep the receiver hook down until after the contacts H were closed when the Telomat was "called up". Otherwise the ringing potential was short-circuited when the hook was raised and the Telomat failed to start up. It is also necessary that the insulated cam "I" be long enough so that it will not "coast" by due to the inertia of the motor. To overcome this difficulty an additional set of contacts G was arranged to operate with contacts H. Since the former contacts are connected in series with the supply of the receiver hook lifting coil the ringing potential cannot be interrupted until the contactor arm J is well under way. The center set of contacts on relay S₄ are connected in parallel with the set G so that when the Telomat is locked in the hook will stay up while the arm goes by the stopping position.

The coil terminals of the relay S₅ are brought out to a jack into which sets plug P (see photo A). This relay can be connected directly to the ringer terminals in the telephone box or across the incoming line with a condenser in series.

The terminals of the five controlled circuits are accessible at the plug-in sockets shown also in photo A.

Referring to photo I the arrangement of the telephone and adjustable height supporting shelf can be seen. Below the shelf can be seen the two line fuses LL, the line switch N, and the power input plug P.



The First Trial of the Telomat

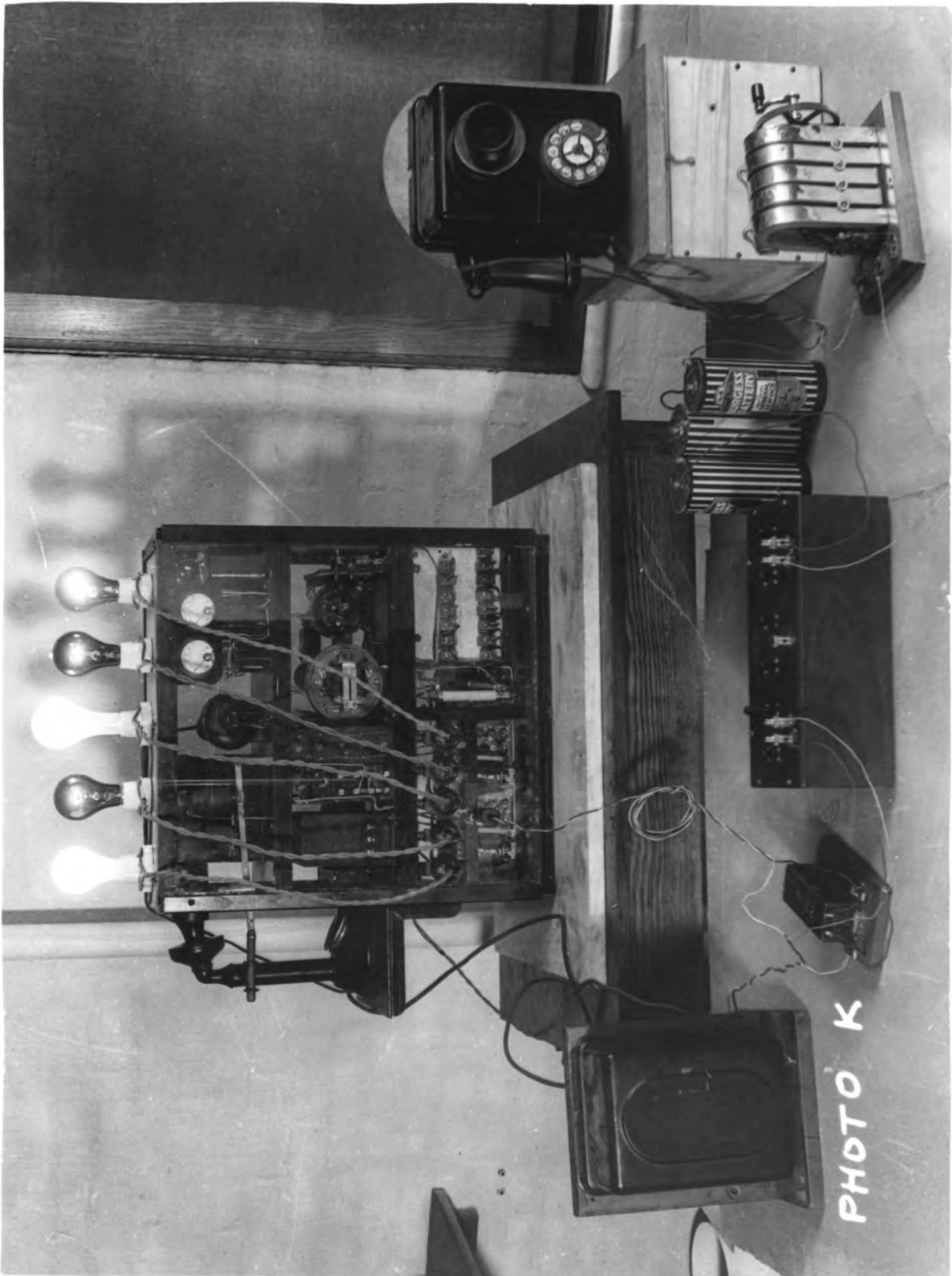
During the Engineering Show of February 3, 4, and 5, 1931, the Telomat was set up in the engineers' reading room for demonstration. Photo J shows the general layout of the exhibition including the five devices operated through a short telephone line. The operator sat in the chair on the left just behind the sun lamp and used the desk telephone on the table. By calling up the Telomat he turned on and off the sun lamp, an electric phonograph, a bridge lamp, a desk lamp, and a fan by appropriately whistled notes into his telephone.

Only three difficulties were encountered during the three days' trial. First, a new operator had not learned the whistle notes sufficiently well (this was no fault of the machine); second, the contacts on relays S_2 and S_3 operated mechanically but did not make good electrical contact; and third, there was insufficient d.c. voltage from the Tungar tube to operate the alternate impulse relays reliably.

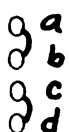
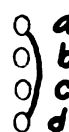
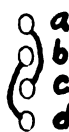
The first difficulty was overcome by a little practice on the part of the operator.

The second was overcome by equipping the relays in question with tungsten contacts.

It was afterwards found that the third difficulty was due to low supply voltage and to avoid trouble in the future an additional 10 volt primary winding was added to the power transformer. The terminals for connecting in this winding



are shown as a, b, c, and d on the connection diagram and in photo C. Now the Telomat can be operated on any voltage from 105 to 135 volts. Below are shown the proper connections for various supply voltages:

Voltage Range	105-115	116-126	127-135
Connections			

Instructions for Setting up the Telomat

The Telomat should be placed on a level surface with rigid supports as the machine weighs nearly 100 lbs. It may be necessary to remove some of the glass plates in order to make all the adjustments. First, connect a supply of "110 a.c." as shown by plug P in photo I. This same voltage is supplied to the plug-in receptacles in front when the Telomat is operated.

Next adjust the telephone on its supporting shelf as shown in the photos. It may be necessary to raise or lower the shelf by loosening the two nuts underneath. Take pains to adjust the counter weight and position of the telephone so the hook lifting mechanism operates freely. Place the receiver in its position as shown in photo D; there is a place for the receiver cord to pass through the top glass.

Connect plug P (photo A) directly to the terminals of the telephone ringer (bells) or across the incoming line in series with a 1 or 2 mf. condenser. Photo K shows a good arrangement of connections that will operate satisfactorily.

If only two telephone subsets are used (one for sending orders and one for the Telomat to answer) they may be connected by joining in series the lines from the two phones, three dry cells, and a hand-cranked telephone generator with short-circuiting contacts. The generator must be connected so that it will cut in on the line when it is cranked and will short-circuit its own terminals when not in use. There are many other setups or arrangements of telephone subsets that can be used. The above as shown in photo K is one of the simplest for two subsets.

Finally, connect five or less devices to the plug-in receptacles on the front. Another typical layout is shown in photo J. For testing or experiment, five 110 volt colored lamps can be used to advantage.

The Telomat is now ready for operation.

How to Operate the Telomat

Be sure that the switch N (photo "I") is closed; then call up the Telomat by cranking the generator for at least 2 or 3 seconds. Usually the crank will turn harder as soon as the Telomat responds by lifting the receiver hook. It is better not to send signals the first time but simply observe how the machine functions. The filaments in all the vacuum tubes will be lighted and the motor and contactor arm will be operating. The meters on the front will register 1 or 2 milliamperes and the receiver hook will be held up. After the contactor arm makes one revolution (it takes 10 seconds) the machine will shut itself off.

Now call up again, and whistle a low note of about 1200 cycles per second (the third D above middle C on a piano) into the transmitter. It may be necessary to vary the pitch or the note somewhat but when the right tone is sounded the left hand milliammeter will give a deflection of several divisions and relay S₄ will click as it closes in.

Soon after this relay closes buzzer signals will be heard in the receiver and the Telomat will not stop itself as it did before. As the contactor arm begins its cycle or revolution each time, a long buzz is heard and at regular intervals, short buzzes. The sounds can easily be represented by the following graph:

<u>Long</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
		10 seconds			
		(one rev. of arm)			

In order to energize any one of the five circuits it is only necessary to whistle a high note of about 1600 cycles per second (the third G sharp above middle C on a piano) just after the short buzz corresponding to that circuit. The right hand milliammeter shows when the proper high note is sounded. Suppose it is desired to energize the third circuit. Listen for the long buzz and then begin counting the short ones that follow. Just after the third short one, whistle the high note and if it is correct the relay can be heard to click in and whatever device is attached to circuit 3 will become energized.

The next time the contactor arm comes around two short buzzes for circuit 3 will be heard instead of one as shown

below

Long 1 2 3 - 4 5

10 seconds

The other circuits are operated in the same way. If circuits 2, 3, and 5 were closed the buzzer signals would be like this

Long 1 2 - 3 - 4 5 -

10 seconds

To open a circuit it is necessary to whistle the high note again at the same time used for closing it. In other words the same note is used to open or close any of the five circuits. For instance, referring to the above graph, if it is desired to open circuit 3 begin listening to the signals; after the long buzz, one short buzz for circuit 1 will be heard and then two more short buzzes in quick succession for circuit 2. Just after the first buzz for circuit 3 whistle the high note which will operate the relay to open this circuit. It is not necessary to wait for the second of the two buzzes; if one whistles soon enough there will be no second buzz. In this manner any of the five circuits may be opened or closed simply by whistling the high note at the proper time during the cycle.

To shut the Teloniat off or "say goodbye" to it, whistle the low note again. The buzzer tones will stop immediately and when the contactor arm comes to the stopping position the machine will shut off. Of course, any of the five circuits which were turned on will remain energized even though

the Telomat is not operating.

In order that a new operator may practice and learn the two whistle notes the contactor arm driving motor may be stopped by operating the switch K shown in photo E. Microphone M₁ (photo A) may be turned over toward the front so that the operator can whistle directly into it and also see the milliammeters which will indicate from 5 to 10 divisions when the proper note is sounded. The click of the relays also tells when the right tone is used.

Once the system of operation and the two notes are learned the Telomat can be operated from another room or from any distant point. It would be necessary, however, to know what device was connected to each of the five circuits.

Trouble Shooting

The following is a list of suggestions for use in case difficulties are encountered in setting up and operating the Telomat:

1. Failure to respond to ringing potential.

Examine the telephone line connections and the connections of plug P (photo A) to ringer. Be sure that power is being supplied to plug P (Photo I) and that switch N is closed. If the ringer circuit is complete the armature of telecode relay S₅ can be seen to move when the generator is cranked. If the power circuit is complete any of the five controlled circuits may be energized by closing their alternate impulse

relays by hand. Finally the contacts of the telecode relay may need adjustment or cleaning.

2. Vacuum tubes light up but motor does not start.

Close the motor switch M (photo E).

3. Receiver hook does not operate.

Adjust the position of the telephone on the shelf and also the counter weight. The Tungar tube may be defective.

4. Failure to respond to whistle notes.

Be sure the telephone system is functioning properly. This can be checked by talking over it. If the amplifier circuit is operating properly the milliammeters will respond as explained before. If they do not some of the vacuum tubes may be defective. The voltages applied to these tubes should be as follows: plate potential for all tubes about 150 volts d.c.; grid voltage for VT₃ and VT₄, -20 volts d.c.; grid voltage for VT₁ and VT₂, -6 to -10 volts.

If the milliammeters do respond see that relays S₂ and S₃ are operating properly. These relays are operated by the current indicated in the meters. If everything functions correctly up to this point the difficulty may be due to the fact that the receiver hook lifting mechanism has not opened contacts D (photo H). In this case the alternate impulse relays will be sluggish in action or will not respond at all. The Tungar d.c. supply should furnish about 150 volts when no whistle notes are being received. This voltage can be measured across the terminals of condenser bank C₉.

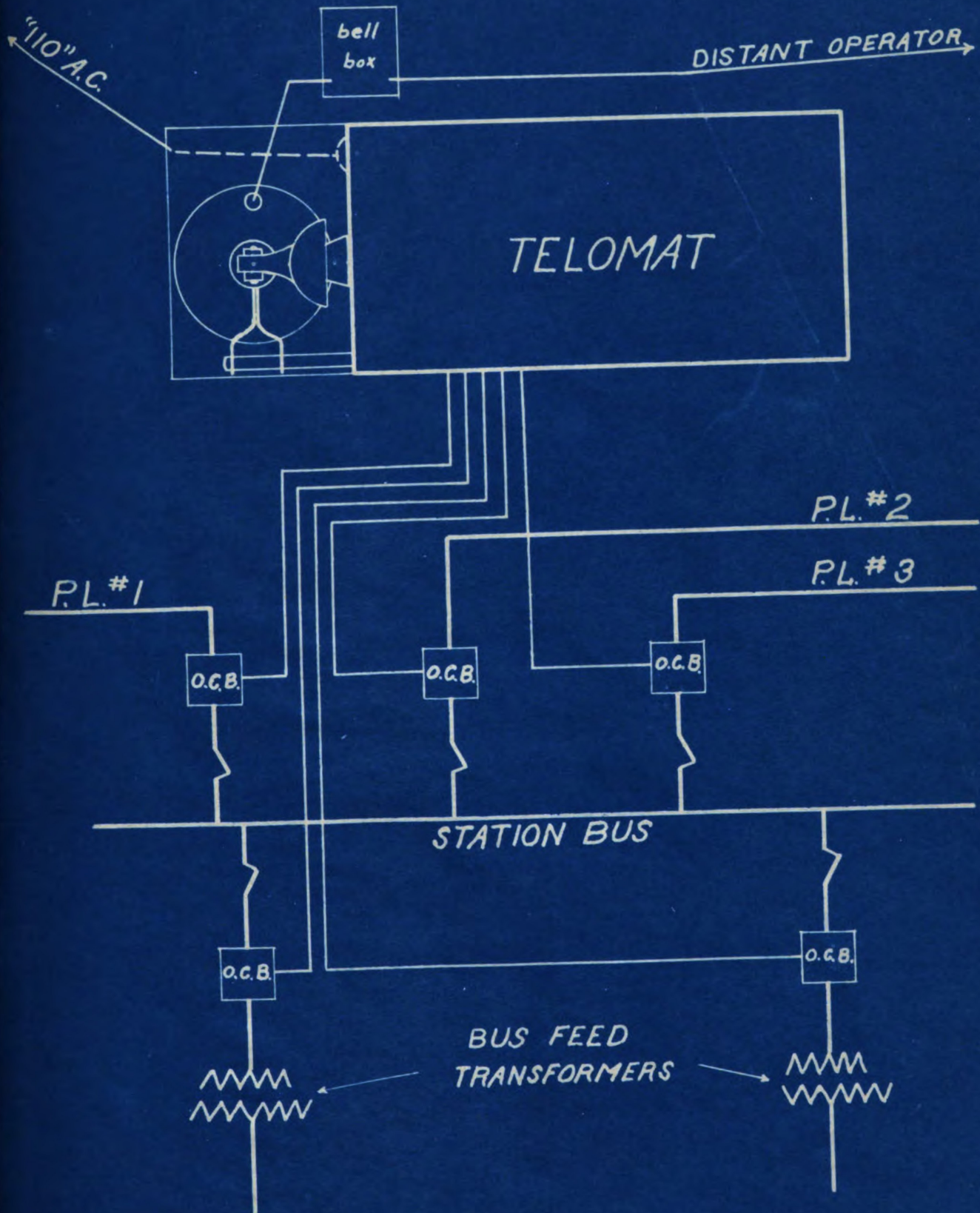
5. Various other suggestions.

The transformer connections a, b, c, and d (photo C) should be correct for the voltage applied. Refer to page 30 for the correct arrangement.

Most telephones have adjustable height transmitters and since the rubber tube Z is also adjustable a good sound proof connection can be had for carrying the buzzer tones.

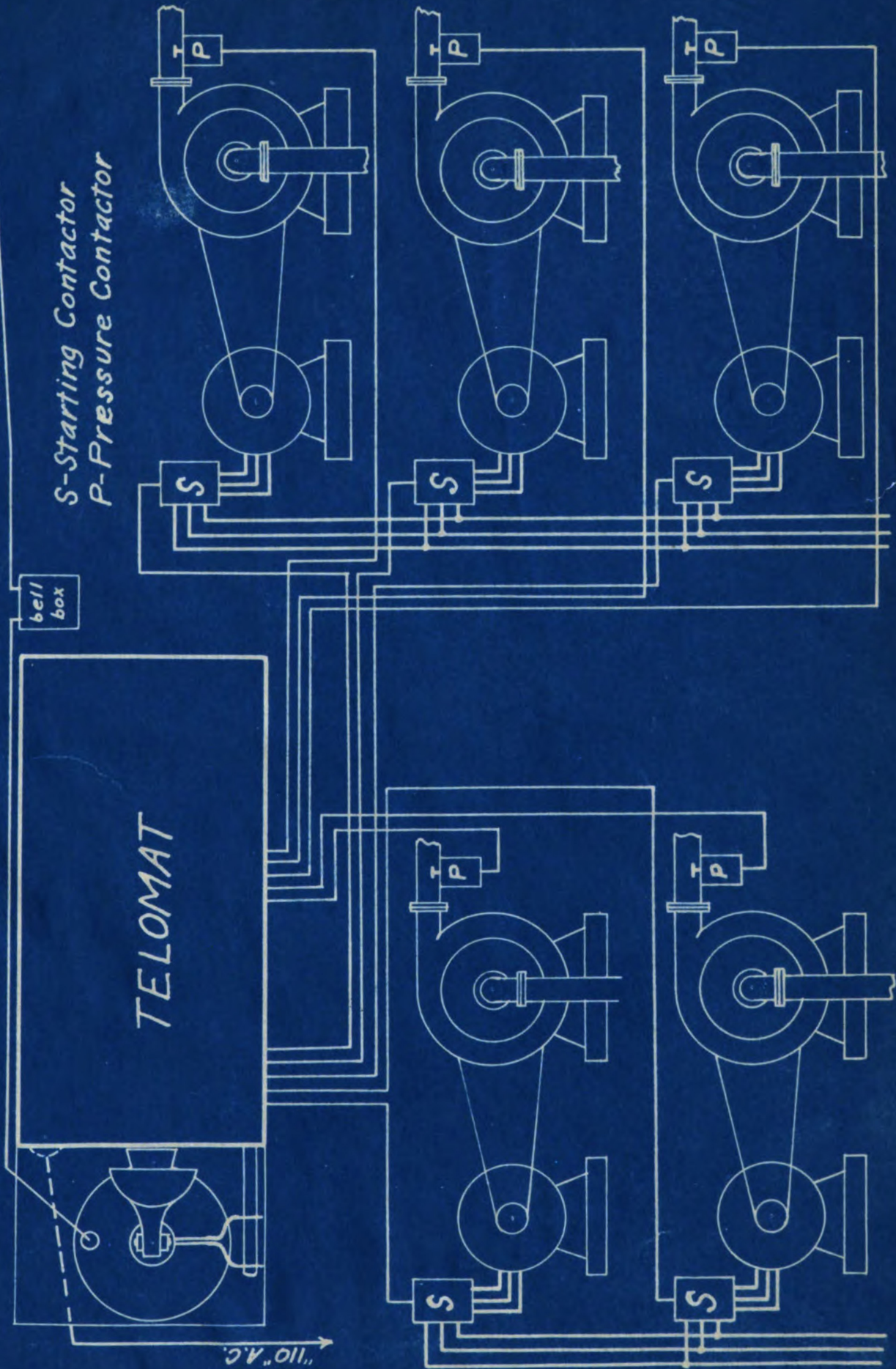
The fuses LL have to be large enough to carry the current for all the controlled circuits as well as 1.5 amperes for the mechanism of the Telomat.

Remote Control of a Substation by Telomat (Schematic Diagram No. 1)

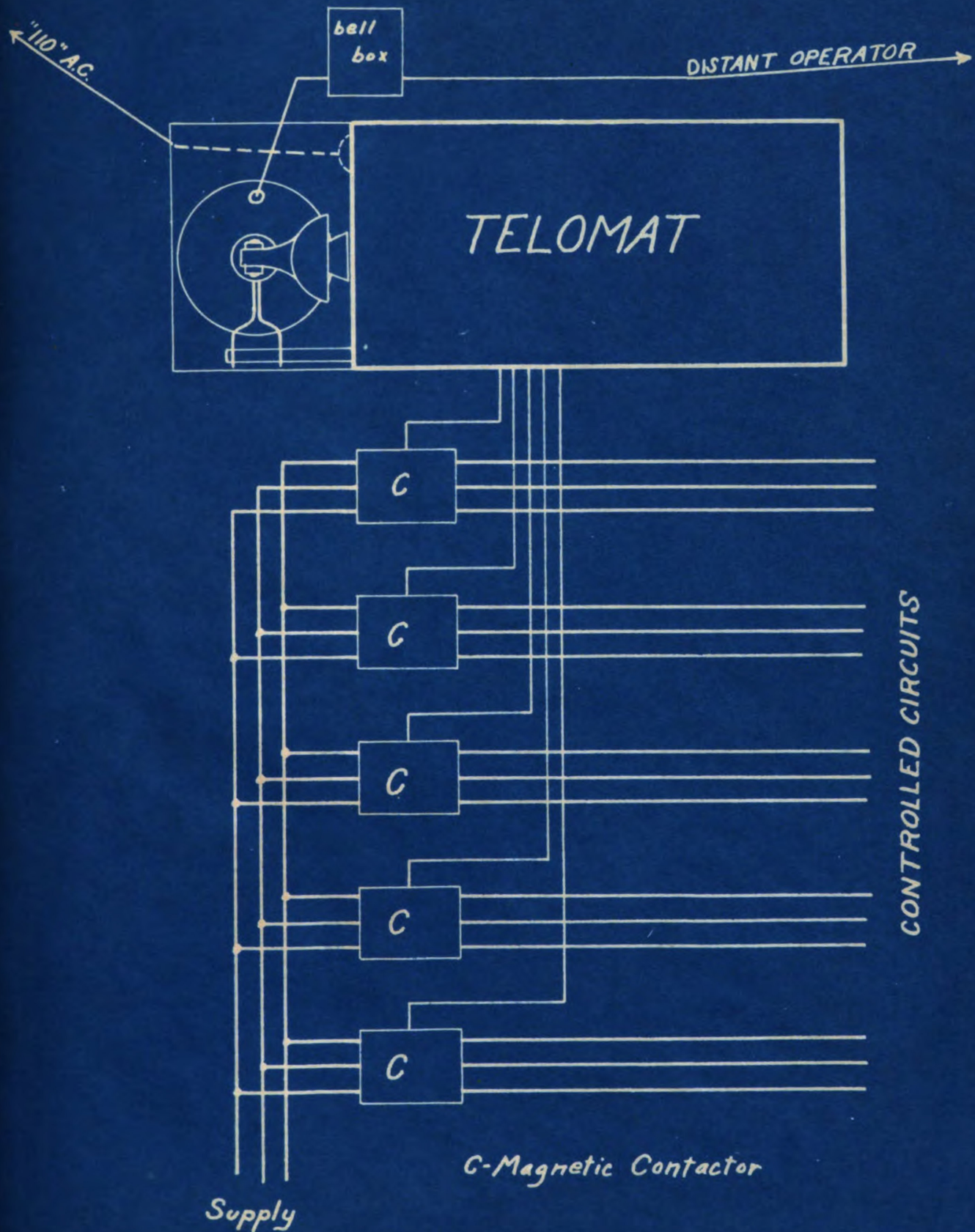


Operation of a Pumping Station by Telomat (Schematic Diagram No. 2)

Distant Operator



Remote Control of a Lighting System by Telomat (Schematic Diagram No.3)



APPLICATION OF THE TELONAT

A. To control a substation.

Public utility companies which distribute electrical energy are continually introducing more and more automatic and remote control systems for simplification in the operation of substations and powerhouses. The advantage of having one man or central office to regulate the distribution of power has long been known and this method is now used by many companies.

On the accompanying schematic diagram No. 1 there is shown a setup using the Telonast for operating a small substation. Only one circuit is necessary between the Telonast and the distant operator and this one circuit may be an ordinary telephone line which is already in existence. Not only can the circuits be opened and closed but also an audible indication of the position of each breaker is given every ten seconds while the Telonast is in operation.

B. Control of a Pumping Station

On schematic diagram No. 2 an arrangement is shown illustrating how the Telonast may be used for the supervisory control of a pumping station. By this method any one of the five pumps may be started or stopped and by means of the pressure operated contactors in the outlet pipes the Telonast is able to tell whether the pumps are functioning satisfactorily or not.

C. Control of a Lighting System

Schematic diagram No. 5 shows how the Telomat may be used for operating a lighting system.

CONCLUSION

During the present day and age science knows no limit in research and in the development of new ways of using and controlling energy. The public accepts the work of the research man and the inventor with awe and admiration. It is eager to admit that "there is nothing that is impossible". Apparently inconsistent with this is the familiar "There is nothing new under the sun." No doubt there is a great deal of truth in both statements because, after all, a great many new inventions and discoveries are based on the application of a number of simple laws which have been known and used for many years.

Likewise with the Telomat. The whole system of operation is built up by the use of a large number of simple laws of electrical engineering. The designer hopes he has developed a machine which will be another step in the present day trend of using remote control devices. The Telomat makes it possible to have remote supervisory control of a number of circuits using the existing telephone system as a medium.

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