MC 241
Box 5 Folder 2

RCA Manufacturing Company, 1939-41

February 28, 1941

Mr. B. J. Thompson
RCA Manufacturing Co.
Harrison, New Jersey

Dear Browder:

Thank you for your many letters. I have written Glover again and hope that we will eventually receive a more stable multiplier with a better signal-to-noise ratio than the present one.

Concerning Mr. Hocker, I would suggest that he makes a very able technical assistant. He is capable of carrying through plans that are well formulated, and in the not too complicated situations often contributes original and valuable suggestions concerning the mechanical features. He is able to build special circuits skilfully and carry through the "engineering plans" of working out constructional details very satisfactorily.

You undoubtedly have all the information you need concerning his formal academic training. I would be inclined to say that he would be most useful in your laboratory as a technical assistant to someone else who did practically all of the original thinking and planning, leaving Hocker only to fill in the details for which he has sufficient originality to serve as a useful function. As you know, it is a great convenience to a man working on research to be able to sketch out the broad features and leave the details up to someone else. This is where he fits in best.

I hope this will be satisfactory

Very sincerely yours,

Wayne B. Notti

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

February 26, 1941

Professor Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

When I was in Cambridge last you spoke to me about electron multipliers. I discussed your requirements with George Morton at Camden. He believes that Dr. Glover's multipliers would be better than anything they have at Camden. I believe that Dr. Glover plans to write you in an attempt to straighten out the difficulties. Unless I hear from you further, I shall assume that everything possible will be done.

Very sincerely yours,

(B.J. Thompson)
Research Laboratories

BJT/ML

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

February 26, 1941

Professor Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

Yesterday your assistant, Mr. Hocker, visited us in connection with his application for a position in our laboratories. Hocker believes that he would be most useful in engineering or development work, but feels sure that he would be effective in the research laboratories working with one of our more experienced men. I should greatly appreciate hearing your opinion as to Hocker's technical equipment, his present abilities, and his probable future field of usefulness. It would be helpful if you could write me concerning this in the next few days.

Very sincerely yours,

(B.J. Thompson)
Research Laboratories

BJT/ML

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

January 16, 1941

Professor Wayne B. Nottingham
Massachusetts Institute of Technology
Department of Physics
Cambridge, Massachusetts

Dear Professor Nottingham:

At Mr. B.J. Thompson's suggestion I am taking over the correspondence relative to your request for electron guns. Referring to your letter of December 16th, I have been authorized to quote you a price of $25. each for special type 912 guns with tungsten filament, completely assembled. For the second alternative namely, to furnish you with a complete set of parts including the stem, I have been authorized to quote you a price of $7.50 each. Certain of the parts which can be furnished for this price are already made up into sub-assemblies ready for the mounting. Because of our factory setup it would be more expensive to eliminate these sub-assemblies and furnish each part individually. In other words the price of $7.50 represents the lowest price we can achieve.

With respect to your request for electron guns with oxide coated cathodes, we will be able to furnish you with the type 12AP4 mounts completely assembled, ready to seal in for $7.30 each. Parts for these mounts unassembled can be furnished for $6.10 each. I personally feel that in this case the completely assembled mount would be of more value to you inasmuch as it is our practise to ship these mounts in partially evacuated tubing, thereby providing greater protection for the cathodes during shipping.

Pertaining to the 912 mounts your conclusion regarding the thickness of the filament is correct. It is our practise to use tungsten strip .001" rather than .004" thick as I originally stated. Since there is usually considerable delay in securing this strip we suggest that you obtain a supply direct from the manufacturer. The price quoted does not include the tungsten filament. I am inclosing a sketch showing the layout of the parts for the 912 mount which I think will enable you to assemble the parts quite readily.

Should you decide to order the unassembled parts, it will facilitate the handling of the matter if you will mail your order directed to my attention.

Once again let me apologize for the delay in answering your letter. Should there be any way we can be of further assistance to you, do not hesitate to call upon us.

Yours very truly,

W H Painter

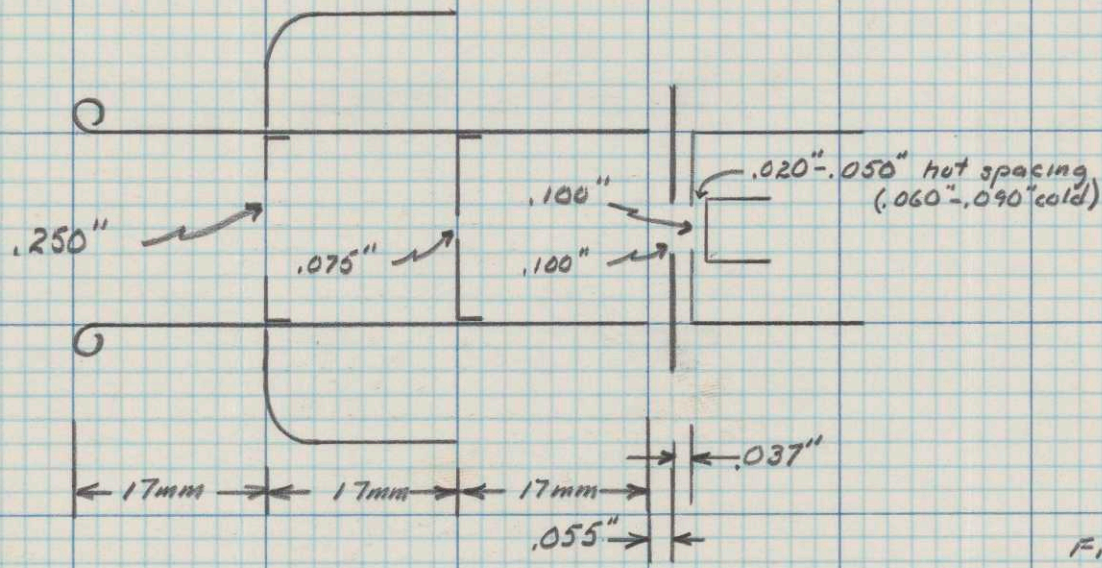
W. H. Painter
Cathode Ray Engr. Laboratory

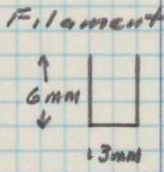
WHP:v
Enc.
CC: Mr. B.J. Thompson

1

Section of Electron Gun for Demountable Setup

Grid-filament spacing should be as small as possible without shorting.





Use .001" x 3mm tungsten strip 15mm long, bent as above. Weld each leg to <u>two</u> of the heavy (.050") stem leads. This leaves only four stem leads for the rest of the mount (1 for P_1; 1 for G_2; 2 for G_1) Use a small glass bead for the third G_1 support.

W H Painter
1-14-41

December 16, 1940

Mr. B. J. Thompson
RCA Manufacturing Co.
Harrison, New Jersey

Dear Browder:

As you no doubt know, Mr. Crawford sent out copies of your reply to Wheeler asking for comments which might be helpful. The enclosed is a copy of my comments in this matter. I would be interested in knowing your reaction to my suggestions.

Another matter is occupying our attention at the present moment and that has to do with the electron guns which we need in the investigation of secondary emission on tungsten. These investigations are actively under way by Messrs. C. W. Mueller and K. McKay. They both have concluded that some flexibility would be added to their work if they could use 912 guns with a tungsten cathode instead of the oxide cathode. You have replied to a request for information concerning this made by Mueller. It seems as though there are three possible solutions to this problem.

The first would be that we use the parts of certain 912 guns which we have and reassemble them over a tungsten ribbon cathode.

The second possibility would be that you furnish us with the unmounted gun, that is, the cylinders and control parts before they are finally attached to the lead-in wires, and that we mount that assembled unit over a tungsten ribbon filament according to the specifications in terms of the location of the ribbon with respect to the first electrode that you might specify.

The other alternative would be that you would prepare a 912 mount on a Pyrex flare, as you have in the past,

except that instead of putting in an oxide indirectly heated cathode, you install a ribbon filament.

The first of these plans could be carried through if you were to give me information as to the spacing requirements, so that we could reassemble certain of our present 912 guns according to the standard requirements. The second plan would depend upon your being willing to furnish us with these assembled parts, and the third plan, of course puts the heaviest demand upon you and asks you to do all the work.

You have kindly furnished us with standard guns in the past at no charge and we have appreciated it. If you could give us three guns under the third plan, I think we could contribute at the most about $15 per gun toward their construction. I know that this amount would hardly cover the cost.

In your letter to Mr. Mueller mention was made of certain guns which you have constructed using ribbon filament tungsten. We note that the thickness of this tungsten was .004" and would like to know why the thinner ribbon would not be better, since I am sure that we could obtain suitable tungsten strip from the Mallory Co. which is only .001" in thickness. If you do not have such strip and would like to have me get it for you and have it bent in the proper form at the Mallory Co., I am reasonably certain that I could get just what you need there.

I hope that it will be convenient to advise me in this matter quite soon.

Sincerely yours,

Wayne B. Nottingham
Associate Professor of Physics

WBN:W

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

November 27, 1940

Mr. Charles Mueller,
Room 6-210,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Mr. Mueller:

In response to your letter of November 23, I am quoting the following comments from Mr. W.H. Painter concerning the use of a tungsten filament in the type-912 electron gun:

"We have supplied to customers type 904 guns with tungsten filaments instead of oxide-coated cathodes. The 904 is similar to the 912 except that it is designed for lower voltage work, i.e., it does not have the special shielding and polishing of the 912. I know of no reason why the same idea would not work in the 912.

"This type of filament will not deliver as much current as the oxide cathode. It is necessary to increase the diameter of the grid and screen apertures to 100 mils, which in turn requires an increase in grid bias for current cutoff. It also results in an increase in spot diameter. As I recall, the last ones we made in 904 guns had about the following characteristics:

E_{b2} = 3,000 volts
E_{b1} = 650 volts approx.
E_{c2} = 150 volts
E_{c1} for current cutoff = 90 volts approx.
I_{b2} at zero bias = 170 microamps
Line width at zero bias (60-cycle scanning)
= 1/8 in. approx.

Of course, with higher voltages, higher currents and possibly some improvement in focus can be expected.

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Harrison, New Jersey

"A further feature worthy of note is that the center 2 in. of the screen is quite brightly lighted by light radiated from the filament. I know of no simple way to overcome this.

"To make the filament, tungsten ribbon about 4-mils thick and 4-mm wide was bent into a rectangular U with a 3-mm flat end and two 6-mm legs. The heating current is high, of course, so two stem leads were used in parallel for each filament leg."

We trust that this information will meet your requirements; if not, we should be happy to give you such other assistance as we can.

Very truly yours,

B.J. Thompson

(B.J. Thompson)
Research Laboratories

BJT/ML

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

October 3, 1940

Dr. Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

As you may know, we have employed very few engineers or physicists in the last few years in our research laboratories. While there has been no considerable change in our immediate prospects, I, personally, feel that it is quite likely that several openings may develop in the next few months. I should greatly appreciate, therefore, your calling to my attention any good men whom you know to be available.

Our greatest interest would be in physicists or electrical engineers with some experience in ultra-high-frequency work. Any promising young electrical engineer or physicist with a keen interest in experimental work of the general type which we do would be a possibility from our viewpoint. We may be interested in both Ph.D's and men with less training. A man who could work effectively under close supervision would be useful in some of the jobs which may develop.

We should be especially interested, of course, in men with whom you have had direct contact, for your opinion would carry great weight with us. Any help you can give us will be greatly appreciated.

Very sincerely yours,

(B.J. Thompson)
Research Laboratories

BJT/ML

12-21-39

Mr. B. J. Thompson
Re: W. B. Nottingham letter 11-29
M.I.T.

I have reviewed the cht.

Notice the capacity attenuator is used from the 884. This improves the frequency response of the output cht but then some of the benefit is lost in the potentiometer. (High frequencies are shunted). Suggest if convenient the pot be fixed as small resistors usually have less capacity. Also the series resistor R_{10} limits high frequency response.

For oscillation stability the grid resistance should be kept low. R_3 is ok but R_2 may be a little too high for best operation at some settings.

Our ratings do not permit application of over 300 volts to the 884 yet the supply is 560. During operation only the much lower plate voltage is applied (drop thru R_8 etc.) so life will ordinarily be good so long as the "warm up" time (non conduction) doesn't happen too often.

Better stability should be obtained with less than 1 ma 884 plate current. (His max. about 1.8 ma)

Philip A. Richards

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

January 10, 1940

Professor Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

I referred the circuit diagram of a sweep circuit enclosed with your letter of November 29 to Mr. Burnett and Mr. Richards, of our organization. These gentlemen have had much more experience with such matters than I have. I am enclosing Mr. Richards's penciled comments, which I hope will be of some value to you.

It appears that your circuit is very good indeed. I should think it would be very good to publish your paper concerning it in Electronics. I can suggest no better journal for the purpose.

I am afraid I have done a very slow job in replying to your letter. I hope that this will not bring me into too serious ill favor with you, for I am beginning to get my desk cleaned off again and hope to be able to do better in the future.

Very sincerely yours,

(B.J. Thompson)
Research and Engineering Department

BJT/ML
Enc.

November 29, 1939.

Mr. B. J. Thompson
RCA Manufacturing Co.
Harrison, New Jersey

Dear Browder:

I am enclosing a circuit diagram of a sweep circuit the development of which I have just finished. The features of this circuit are that the range covered is about 6 to 20,000 cycles and the amplitude is 400 volts with practically no distortion. The system "locks in" very easily and seems to be very stable even when not locked in. The amplifier may be used independently, giving a gain of about 1500 when the "decoupling" condensers are connected in, and is flat from about 25 cycles to nearly 160 KC, with a decrease in gain of a factor of 2 between 160 and 200 KC. Without the "decoupling" condensers, the gain is about 330 and is flat from less than 10 cycles out to about 160 KC.

As far as my experience goes, this sweep circuit with its amplifier is the best one that I have seen capable of giving a linear sweep of as great an amplitude as 400 volts. You may have seen some better ones, or you may see some obvious improvement which I might be able to make in this one. If you do, I would appreciate your suggestions or criticisms.

I am considering submitting a paper showing the details of this development for ELECTRONICS. Would you consider this the best place to publish this type of paper?

A few days ago I sent you a copy of Edgerton's new book, FLASH; I hope it was not lost in the mail. If you did not receive it, please let me know so that I can try to trace it.

Sincerely yours,

Wayne B. Nottingham

WBN:W

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

November 21, 1939

Professor Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

In response to your letter of November 13, I am enclosing a sheet which describes the factory exhaust procedure for the type-912 cathode-ray tube. I presume from this you can abstract enough information to be of assistance to you in exhaust and activation.

I am unable to give you any useful information concerning focusing electrodes beyond what was included with my last letter. If you run into trouble, I shall try further to dig up something which might help.

Very sincerely yours,

(B.J. Thompson)
Research and Engineering Department

BJT/ML
Enc.

EXHAUST SPECIFICATIONS

Equipment

The equipment consists of one manifold with one position connected to a mercury pump backed by a small Kinney pump. Also an Ionization gauge on manifold.

Schedule

1. Put heat on mercury pump and raise liquid air trap.
2. Before sealing on tubes, close stop cock.
3. Seal tube on manifold so that the deflection plates stand approximately 45° with a vertical plane (front to back of position) thru the manifold and so that the mount will be centered in the mount coil when coil is raised.
4. Open stop cock slowly and test for leaks by applying spark coil to manifold only. Care must be taken not to allow any red glow to appear in the tubes.
5. Place heating element around stem and pull oven down. Set regulator oven → at *540°C.
6. When temperature of oven reaches approximately 400°C, lower liquid air. Raise liquid air after trap has become approximately room temperature.
7. → Bake at *540°C for a minimum of 2 hours or more if necessary to bring gas pressure below 2 /μa on ionization gauge.
8. Raise oven and inspect fluorescent screen for spots and smears. If smeared or spotty remove tube from pumps.
9. Remove heating element from around stem and with regulator set at 300°C keep oven raised only sufficiently to allow H.F. treatment of parts.
   Caution: When treating parts with H.F. be sure all leads of tube are separated and shielded from touching coil.
10. Heat deflection plates at approximately 900°C for 4 minutes.
11. Degasify getter assembly, flashing a slight amount of getter to prove thoro degasing of assembly.
12. Heat mount at 700°C (as indicated by carton lamp temperature indicator) for a minimum of 30 minutes or longer if necessary to reduce pressure below 2.0 microamps on ionization gauge.
    Caution: (Use brass ring inside H.F. coil to prevent nickel bell shield on mount from getting hotter than 900°C. Keep brass ring shield from touching coil and tube neck.
13. → Heat control grid to *950°C for 3 minutes before beginning to activate.

Time			I_f		
20	seconds	at	1.6	amps.	
20	"	"	1.7	"	
20	"	"	1.8	"	
20	"	"	1.9	"	(Tubes without a screen grid take
20	"	"	2.0	"	I_{b1} readings at 500 volts)
20	"	"	2.1	"	
20	"	"	2.3	"	
20	"	"	2.5	"	
1	minute	"	2.6	"	
1	"	"	2.6	"	20 volts on the grid
1	"	"	2.6	"	35 "
1	"	"	2.6	"	50 "

Turn H.F. off.
Lower grid voltage to 10 volts and raise I_f to 3.0 amps for 45 seconds.
Turn grid voltage off.

SCHEDULE (Cont'd)

14. With If = 2.1 and 250 v. on No. 1 and No. 2 anodes tied together, and with No. 1 grid tied to the cathode, read anode current. Current must be 400 microamps or more. If current does not reach 400 microamps after a slight aging, tube is rejected.
15. Check Emission.
16. If Emission is below 2 Ma repeat steps 13 to 15 inclusive.
17. Degasify getter assemblies and flash one getter.
18. When pressure is .2 µa or less, tip off.
19. Turn stop cock off in preparation for next tube.

**Note: Temperature tolerance = 30°C.

912

High-Voltage, High-Vacuum Electrostatic Type

The 912 is a high-vacuum cathode-ray tube with a fluorescent-viewing screen five inches in diameter. This tube, designed for oscillographic applications, is provided with two sets of electrostatic plates for deflection of the electron beam. The 912 produces a brilliant, luminous spot having a greenish hue, and is suitable for the observation and photography of recurrent and transient phenomena. This cathode-ray tube is especially suited for the photography of high-speed transient phenomena and for the observation or photography of high-speed recurrent phenomena, because the high voltages at which it is designed to operate permit the use of an unusually high power input to the fluorescent screen during the short interval of screen excitation.

The electron source of the 912 is a substantial cathode indirectly heated. The cathode, control electrode (grid No.1), and focusing electrodes which function also as accelerating electrodes, constitute an electron gun for projecting a beam of electrons upon the fluorescent screen. The resulting luminous spot, easily visible in a brightly-lighted room, can be regulated as to size and intensity by suitable choice of electrode voltages.

The two sets of electrostatic plates located within the apex of the bulb cone produce fields at right angles to each other, and consequently deflections at right angles. One set serves to reproduce the phenomena under observation; the other is used for the time sweep.

The 912 is not only very useful for the recording of extremely high-speed phenomena, but also, due to its coated-type anode No.2, is particularly suited for investigations where it is desirable to minimize the loading effect of the deflecting-plate resistors on external circuits.

CHARACTERISTICS

HEATER VOLTAGE (A.C. or D.C.)	2.5 Volts
HEATER CURRENT	2.1 Amperes
FLUORESCENT-SCREEN MATERIAL	Phosphor No.1
PATTERN COLOR	Greenish
DIRECT INTERELECTRODE CAPACITANCES:	
Control Electrode to All Other Electrodes	14 *max.* μμf
Deflecting Plate D_1 to Deflecting Plate D_2	3 *max.* μμf
Deflecting Plate D_3 to Deflecting Plate D_4	1.5 *max.* μμf
OVERALL LENGTH	17-15/16" ± 3/8"
MAXIMUM DIAMETER	5-5/16"
BULB (For dimensions, see page 12)	J-42
ANODE No.2 CAP	Medium Metal
DEFLECTING-PLATE CAPS (Four)	Small Metal
BASE (For connections, see page 12)	Medium 5-Pin Ceramic

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RCA Manufacturing Co., Inc.

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

HIGH-VOLTAGE ELECTRODE (Anode No. 2) VOLTAGE			15000 *max.*	Volts
FOCUSING ELECTRODE (Anode No. 1) VOLTAGE			4500 *max.*	Volts
ACCELERATING ELECTRODE (Grid No. 2) VOLTAGE			250 *max.*	Volts
CONTROL ELECTRODE (Grid No. 1) VOLTAGE			Never Positive	
GRID VOLTAGE FOR CURRENT CUT-OFF *			-125 *approx.*	Volts
PEAK VOLTAGE BETWEEN ANODE No. 2 AND ANY DEFLECTING PLATE			7000 *max.*	Volts
FLUORESCENT-SCREEN INPUT POWER PER SQ CM			10 *max.*	Milliwatts
TYPICAL OPERATION:				
Heater Voltage	2.5	2.5	2.5	Volts
Anode No. 2 Voltage	5000	10000	15000	Volts
Anode No. 1 Voltage (Approx.)	1000	2000	3000	Volts
Grid No. 2 Voltage	250	250	250	Volts
Grid No. 1 Voltage	Adjusted to give suitable luminous spot			
Deflection Sensitivity:				
Plates D_1 and D_2	0.083	0.041	0.028	Mm/Volt D.C.
Plates D_3 and D_4	0.102	0.051	0.034	Mm/Volt D.C.

* With maximum voltage applied to Grid No. 2, Anode No. 1, and Anode No. 2.

INSTALLATION

The *base* pins of the 912 fit a standard, five-contact socket, the mounting of which should preferably be made adjustable. The socket can be installed for the operation of the tube in any position. It is especially important that it should be made of good insulating material; a type of socket having insulating baffles between contacts provides an additional factor of safety. Base connections and essential dimensions of the 912 are given on page 12.

The *bulb* of this tube, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is employed to minimize the effect of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized. Anode No. 2 consists of a conductive coating on the inner surface of the conical portion of the bulb. This coating provides some electrostatic shielding and has even more important advantages, as explained in the fifth paragraph under APPLICATION.

The *heater* is designed to operate at 2.5 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. *In the usual circuit where the design is such as to cause a high potential difference between the heater winding and ground, the heater winding should be adequately insulated to withstand the maximum high voltage that will be applied.*

The *cathode* is connected within the tube to one side of the heater. The terminal for this common connection is base pin No. 5, to which grid and anode returns should be made.

The *fluorescent screen* employed in the 912 is of the phosphor No. 1 (medium persistence) type. It has good visual and photographic properties as well as high luminous efficiency.

The d-c *supply voltages* for the electrodes may be conveniently obtained from a high-voltage, vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type, although the latter will usually provide a more economical design. For the same reason, the filter requirements are simple. A 0.25 to 1.0 μf condenser will ordinarily provide sufficient filtering. If this is inadequate for a particular application, a pi filter is recommended.

Two sets of *electrostatic plates*, producing fields at right angles, are located within the apex of the bulb cone to provide for deflection of the electron beam. The electrostatic field of each pair of deflecting plates deflects the beam parallel to the axis of the field; therefore, the deflections produced by the two fields are at right angles. In order to maintain each set of plates at essentially the d-c potential of anode No. 2, each plate of each set should be connected through a resistor of two to fifty megohms (depending upon the application) to the anode No. 2 terminal cap (ordinarily grounded). This arrangement, when suitable resistor values are chosen, assists in preventing the pattern on the viewing screen from being distorted by d-c potentials built up on the deflecting plates. In general, the resistance of the deflecting-plate resistors should be as low as external circuit conditions will permit. If, during operation, the zero axis should be permanently deflected, it is usually because the beam current is too high for the resistors used. The beam current should ordinarily be kept low. When it is necessary to use a high value, as may be required for some photographic work, the value of the deflecting-plate resistors should be reduced so that the zero-axis shift will be minimized. If desired, the deflecting-plate resistors can be connected to a variable d-c voltage to compensate for the shift, or to provide a pattern-centering adjustment.

The deflection sensitivity of each set of plates for typical anode No. 2 voltages is given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

The high voltages at which the 912 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions include the enclosing of high-potential terminals and the use of "interlock" switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required. In most installations it is recommended that the positive high-voltage terminal be grounded, rather than the cathode terminal. With this method, which places the cathode and heater at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

In the use of cathode-ray tubes, it should always be remembered

that high voltages may appear at normally low-potential points in the circuit, due to condenser breakdown or to incorrect circuit connections. Therefore, before any part of a cathode-ray tube circuit or its associated circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

The *cathode-ray oscillograph* is an instrument adaptable to a wide variety of applications. An oscillograph employing the 912 is particularly useful in certain special oscillographic applications where the unusual design features of the 912 are fully utilized. Among these are the photography of extremely high-speed transient phenomena and the investigation of high-impedance circuits where loading due to the deflecting-plate resistors and where beam distortion due to d-c potentials built up on the deflecting plates must both be minimized.

A *circuit* illustrating the use of the 912 in an oscillograph is shown on page 7. The electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of two to five milliamperes is usually satisfactory; values substantially larger may require the use of more filtering than that provided by a single condenser shunted across the d-c supply. With small bleeder currents, a single condenser filter is usually adequate. A variable d-c voltage for the control electrode, for grid No.2, and for anode No.1 can be obtained from potentiometers in the bleeder circuit. One set of electrostatic deflecting plates is used for the phenomena under observation; the other set, for the time sweep which serves to spread the tracing across the fluorescent screen.

The 912 possesses a number of unusual possibilities as a result of the very high voltages at which it is designed to operate. It is particularly well suited for the observation or photography of extremely high-speed recurrent phenomena and for the photography of high-speed (in the order of a few micro-seconds) transient phenomena. In applications of the latter type, a relatively high input to the fluorescent screen can be obtained for the short interval required for the recording. The high anode No.2 voltage produces a high-speed electron beam, which in turn is capable of producing on the fluorescent screen a relatively high-intensity spot of small size.

The high speed of the electrons makes their transit time between the two sets of electrostatic deflecting plates very short. This makes the 912 suitable for use at much higher frequencies than lower-voltage cathode-ray tubes.

Due to the coated type of anode No.2 employed in the 912, most of the electrons returning from the viewing screen are collected by this anode and do not reach the deflecting plates. Therefore, a large beam current can be used with high-impedance deflecting-plate

circuits without appreciable beam distortion due to d-c potentials built up on the deflecting plates.

The 912 is designed to provide as high a current in the electron beam as is consistent with good focusing qualities. This high-current capability is a distinct advantage for obtaining high brightness of patterns covering considerable area, but must be used with caution when the spot traverses slowly any portion of a large pattern or when the pattern size is small. In such cases, particularly when recurrent phenomena are involved, a pattern, or some portion of it, having too high a power input per unit area may exceed the rating of the screen. A "slowly moving spot" is tentatively defined as a spot which is traveling slowly enough to be seen *as a spot*, rather than as a trace or line. With patterns of this type, the power input to the fluorescent screen should be limited as in the case of a stationary spot.

It is important to note that the maximum input power to the fluorescent screen should not exceed 10 mw per sq cm, except for short-interval operation as explained in the paragraph on high-speed photographic work. The use of screen-input power in excess of this value will adversely affect the fluorescent coating, depending on the magnitude and the duration of the power input. The resultant injury to the screen may be a temporary loss of sensitivity, or a permanent destruction of the active screen material.

A high-intensity spot should be kept in motion by means of an a-c voltage applied to the deflecting system, in order not to exceed the maximum fluorescent-screen input rating. Until this voltage is applied, the screen-input power should be kept low, either by the application of a high negative control-electrode (grid No.1) bias or by removal of the voltage from anode No.2.

Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No.2 voltage to anode No.1 voltage. Ordinarily, focusing is accomplisned by adjustment of anode No.1 voltage; in special cases, adjustment of the grid No.2 voltage may be desirable.

Regulation of *spot size* and *intensity* can be accomplished by varying the anode No.2 current or voltage. The current to anode No.2 can be increased by decreasing the bias voltage applied to the control electrode (grid No.1). An increase in anode No.2 current increases the size and intensity of the spot. An increase in the voltage applied to anode No.2 increases the speed of the electrons, which increases spot intensity and decreases spot size. When any of these adjustments are made, consideration should be given to the limiting voltage and power ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

In applications involving *extremely accurate measurements*, the anode No.2 current should be reduced to the minimum value consistent with the desired brilliance of pattern. Where high brightness is an important consideration, the voltage applied to anode No.2 may be increased to the maximum rated value. This procedure, however, is

not always desirable, because the greater speed of the electrons in the beam causes reduced deflection sensitivity. The use of a suitable hood around the viewing screen will help to eliminate extraneous light and, other conditions being equal, will increase the effective brightness of the pattern.

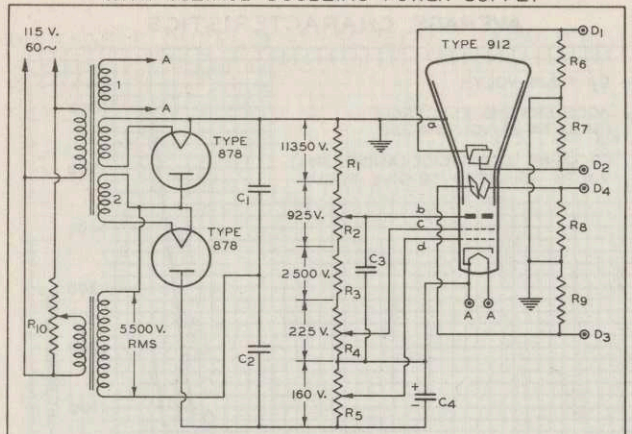
Photographs of phenomena appearing on the viewing screen of the 912 can be made with an ordinary camera. The photographing is done preferably in subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the background. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, the magnification of the pattern, and the brightness of the pattern. Where transients are to be photographed, maximum brightness and a short exposure are required; where recurrent waveforms (suitably synchronized with the time-sweep frequency) are to be photographed, low brightness of pattern can easily be compensated for by longer exposure. The use of panchromatic film may be preferable due to its greater sensitivity at the longer wavelengths of the spectrum of the fluorescent screen, although verichrome film gives excellent results.

For *high-speed photographic work* involving non-recurring phenomena, it is permissible to exceed the rated maximum fluorescent-screen input power per square centimeter for the short interval required to make the exposure. The extent to which the anode No.2 current may be increased without harming the screen is a direct function of the rate of beam travel and of pattern size, and an inverse function of time. Short-interval operation with increased input can be obtained by means of a temporary decrease in the control-electrode voltage. A switching arrangement should be provided to switch the control-electrode voltage rapidly between two different negative values. The exposure is made while the voltage is at the less negative value. The use of suitable condensers across sections of the bleeder (note C_3 and C_4 in the circuit on page 7) is helpful in obtaining good voltage regulation when grid-bias switching is employed. Condensers maintain good regulation because relatively large anode currents flow only during the short time interval necessary for the exposure.

RCA

912

TYPICAL OSCILLOGRAPH CIRCUIT USING THE 912 WITH VOLTAGE-DOUBLING POWER SUPPLY



C_1, C_2 = 0.5 μf, 10000 V.
C_3 = 1.0 μf, 5000 V.
C_4 = 16 μf, 200 V.
R_1 = 2.5 MEGOHMS, 75-WATT
R_2 = 0.2 MEGOHM, 10-WATT
R_3 = 0.55 MEGOHM, 20-WATT
R_4 = 50000 OHMS, 2-WATT
R_5 = 35000 OHMS, 2-WATT
R_6, R_7, R_8, R_9 = 2 TO 50 MEGOHMS
R_{10} = 100 OHMS, 600-WATT
a = ANODE Nº2
b = ANODE Nº1
c = GRID Nº2
d = GRID Nº1

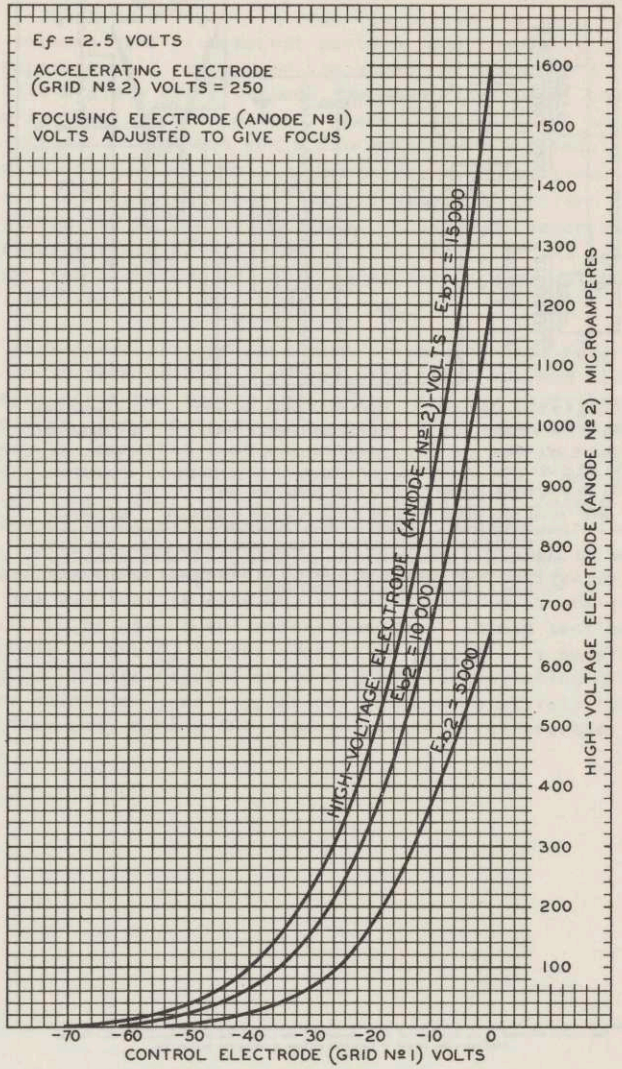
NOTE: AS THE TOTAL VOLTAGE ACROSS THE BLEEDER IS REDUCED BY MEANS OF R_{10}, THE ELECTRODE VOLTAGES ARE REDUCED IN CORRECT PROPORTION, EXCEPT FOR GRID NO.2 VOLTAGE; THIS MAY HAVE TO BE READJUSTED BY THE USE OF DIFFERENT VALUES FOR R_3 AND R_4, THEIR TOTAL RESISTANCE BEING KEPT THE SAME. CONDENSERS C_3 AND C_4 CAN BE OMITTED IF GRID-VOLTAGE SWITCHING (FOR HIGH-SPEED PHOTOGRAPHY) IS NOT CONTEMPLATED. FILAMENT WINDINGS NOS. 1 and 2 SHOULD BE INSULATED FOR 20000 VOLTS.

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

APR. 20, 1937 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 92C-462IRI

912

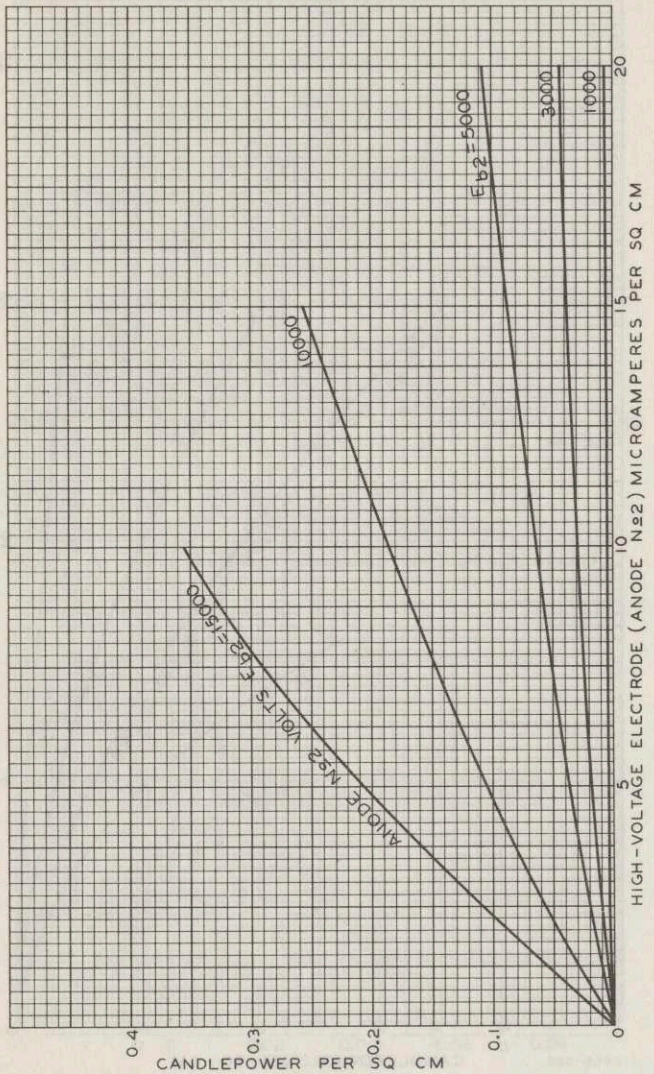
AVERAGE CHARACTERISTICS



JUNE 2, 1936 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 92C-4623

912

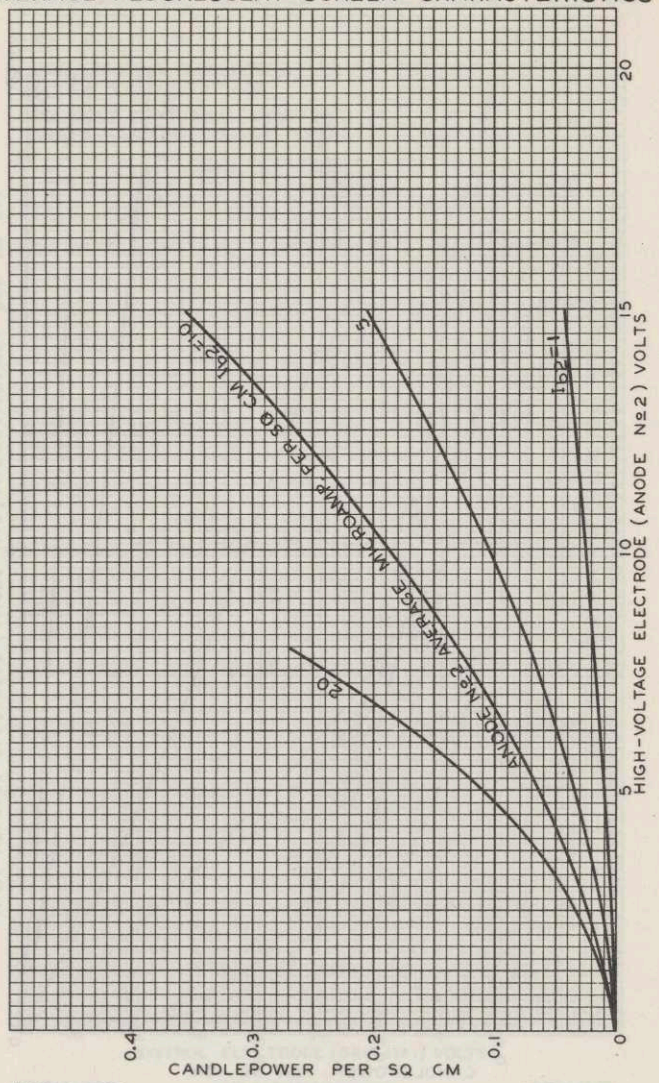
AVERAGE FLOURESCENT-SCREEN CHARACTERISTICS



JUNE 1, 1936 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 92C-4620

912

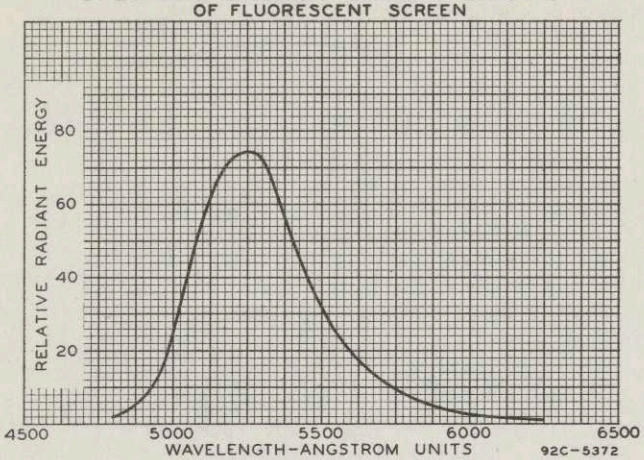
AVERAGE FLOURESCENT-SCREEN CHARACTERISTICS



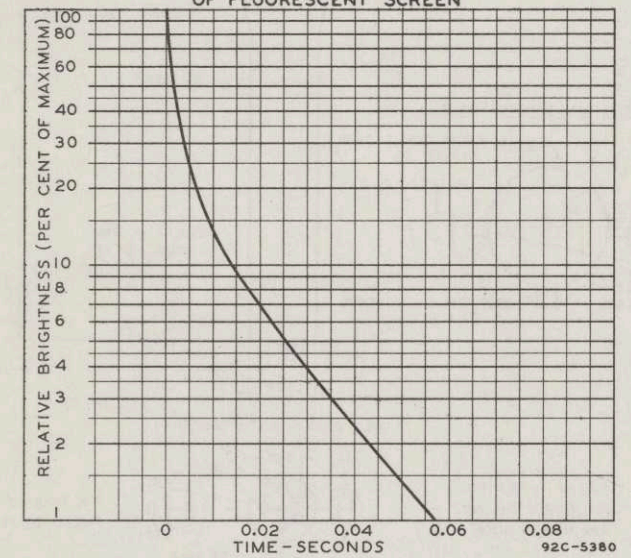
JUNE 2.1936 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 925-4622

TYPES: 903, 904, 905, 906, 911, 912

SPECTRAL ENERGY CHARACTERISTIC OF FLUORESCENT SCREEN



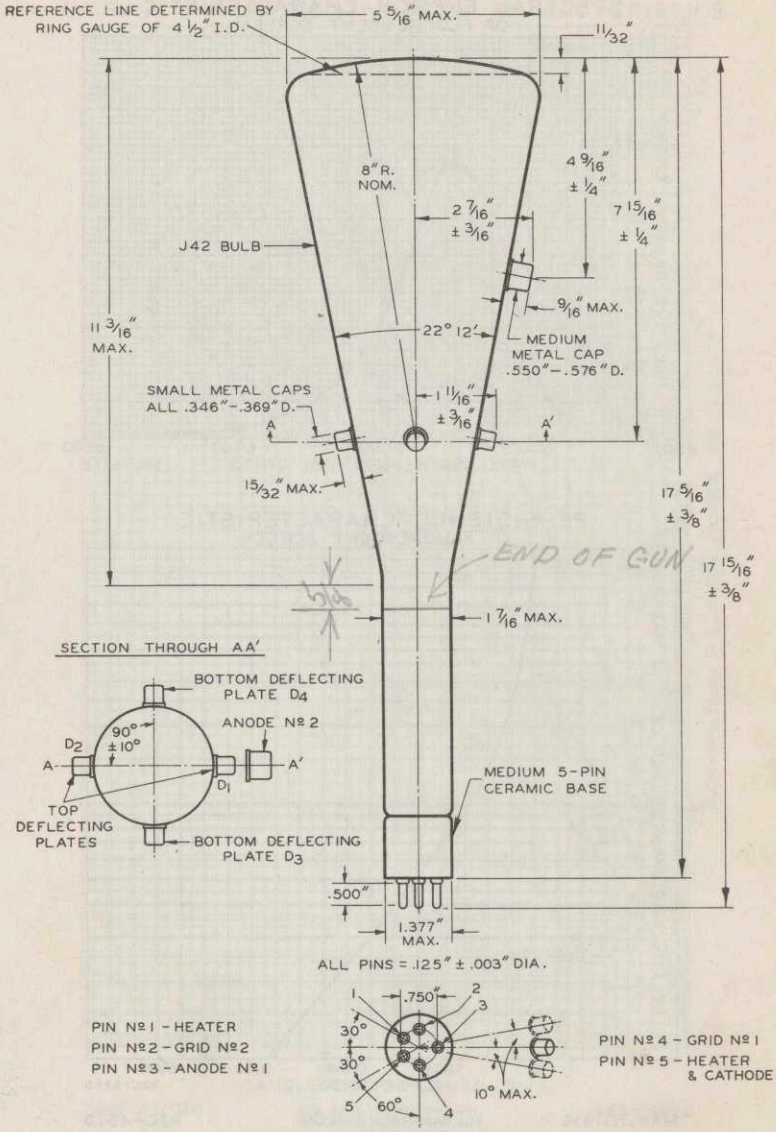
PERSISTENCE CHARACTERISTIC OF FLUORESCENT SCREEN



MAR.11,1936 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 92C-4578

912

OUTLINE DRAWING



BOTTOM VIEW OF BASE

JAN. 27, 1937

RCA RADIOTRON DIVISION
RCA MANUFACTURING COMPANY, INC.

92C-4619R1

Photolithographed in U.S.A.

November 13, 1939.

Mr. B. J. Thompson
RCA Manufacturing Co.
Harrison, New Jersey

My dear Browder:

The three 912 electron guns which you sent me last week arrived in good condition. I would appreciate it if you would send me the activation schedule which you use, and also information as to the nature of the additional electrodes which we might need to use for focusing over a wide range of voltage at a relatively short distance from the end of the gun structure as furnished by you. By a relatively short distance I mean about 10 cms.

In our previous work we used two additional electrodes of the same diameter as the last electrode mounted on the gun. If your men have not had experience that would tell us the best arrangement of electrode length and diaphragm size, we can use the same sizes as we used before, since these worked out successfully for our previous application.

Again I thank you for sending us this material.

Sincerely yours,

Wayne B. Nottingham

WBN:W

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

November 13, 1939

Professor Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

The requirements outlined in your letter of October 28 indicate that our type-912 oscillograph-tube gun is the one which you need. We are sending you three of these mounted on Pyrex stems.

I am enclosing two copies of a technical bulletin on the 912. This bulletin gives you information concerning the gun which may be of value to you. You will note that on page 12 of one of the copies the position of the end of the gun is indicated. In the 912 oscillograph tube the second anode is a conductive coating on the bulb which begins right at the end of the gun. I am informed that this coating must extend for at least an inch and a half toward the screen. You may find it more convenient to make your second anode of a nonmagnetic metallic cylinder rather than to deposit a conductive coating on the bulb.

I hope that these guns arrive in good shape and that you find them satisfactory for your purposes. If you run into any trouble be sure to let me know.

With all good wishes, I am

Very sincerely yours,

(B.J. Thompson)
Research and Engineering Department

BJT/ML
Enc.

FORM 1289-A

TMS

RCA Radiotron Division

RCA Manufacturing Company, Inc.

USTOMER'S RDER NO.

RES. & ENG. DEPT. NO. _____

415 S. FIFTH ST. HARRISON N.J.

SHOP ORDER NO.

DATE 11/9/39

CHARGE TO Below

M. S. ST-4603

SHIP TO Wayne B. Nottingham
Assoc. Prof. of Physics
Massachusetts Inst. of Technology
Department of Physics
Cambridge, Mass.

DATE SHIPPED 11/9/39

FROM Harrison

PPD. OR COLL. PPD

CAR INITIALS & NO.
HOW SHIPPED AND ROUTE EXP PPD

F. O. B. VALUE $15.00

WEIGHT

ACCOUNT DISTRIBUTION

ACCOUNT	VALUE

NO. OF PKGS.	QUANTITY	DESCRIPTION OF MATERIAL	COST UNIT	COST TOTAL	BILLING UNIT	BILLING TOTAL
	3	912 guns (experimental)				
		n/c				

MEMORANDUM OF SHIPMENT

RCA MANUFACTURING COMPANY, INC.
A RADIO CORPORATION OF AMERICA SUBSIDIARY
Harrison, New Jersey

October 26, 1939

Professor Wayne B. Nottingham,
Department of Physics,
Mass. Institute of Technology,
Cambridge, Massachusetts.

Dear Wayne:

I find that we shall be able to furnish you three electron guns, as you request in your letter of October 24. These can be mounted on Pyrex stems. There are several matters which might affect your choice of the various electron guns which we have available. If you wish to use electrostatic deflection you will, no doubt, prefer one of the oscillograph-tube guns with the deflection plates mounted on the stem. If you can use magnetic deflection there will be a wider variety of guns to choose from. In the best Kinescope guns the second anode consists of a conducting coating on the bulb. In some of the smaller tubes the second anode is mounted on the stem. Do you have a preference in this respect? I believe that we once sent you some 912 and 914 guns. Were either of these satisfactory for your present purposes? If you will indicate your preferences in these matters, we shall be able to get the guns off to you very soon.

I appreciate your comments on the electronics conference. I have passed them on to Mr. Lack, and I believe that I can report that he was pleased to hear your comments.

Very sincerely yours,

(B.J. Thompson)
Research and Engineering Department

BJT/ML

October 28, 1939.

Mr. B. J. Thompson
RCA Manufacturing Co.
Harrison, New Jersey

Dear Browder:

I am glad to hear that you will be able to furnish us with three electron guns, but unfortunately I cannot be really certain as to what we want. Perhaps you can decide better than I can.

We do not need deflection plates since we expect to shoot the beam practically straight down the tube and make minor adjustments in its direction by external magnetic fields. We want to be able to focus the spot to a size of the order of 1 mm. diameter or less if demanded, and use it over as wide a range a voltage as possible: that is, as low as about 100 volts and as high as 10 or 15,000. The distance from the gun to the target should be shorter if possible than usually used in the kinescope.

One of my students (Dr. E. A. Coomes) used one of your guns in an application of this kind and found it perfectly satisfactory, but I cannot find at present any records to tell me exactly what type you furnished him. I used the 912 gun for my Schenectady work and found it satisfactory in that connection. If there is any choice between the 912 and 914 which could be decided in terms of what I have given you above, I wish you would choose accordingly.

If further information is needed, please tell me more about the properties of the guns so that we can attempt to choose for ourselves.

Very truly yours,

Wayne B. Nottingham
Assoc. Prof. of Physics

WBN:W

October 24, 1939.

Mr. B. J. Thompson
Radiotron Division
RCA Manufacturing Co.
Harrison, New Jersey

Dear Browder:

First, I want to congratulate you and the other members of your committee for the very fine Electronics Conference which you staged. In many respects I think it is the best one we have ever had. I was disappointed not to be able to attend the session over which you presided, but I felt that the place I was needed most, from the standpoint of my students, was in the session on secondary emission and photoelectric effects, since we have some researches under way which deal with both of those subjects.

That brings me to the second point of this letter,,and that is: would you please be so good as to look into the possibilities of either giving or selling us three electron guns of the standard type, which we may use for studies of secondary emission from metals and also insulators?

I think the possibilities of getting valuable results are sufficiently great to warrent your company supporting us to this extent, but if that proves to be impractical, we shall be glad to pay for the guns. If these could be mounted on a Pyrex flair, it would be to our advantage; on the other hand, if this is not convenient, we can make our own Pyrex-to-Nonex seal.

I would appreciate knowing what you can do for us in this connection at your earliest convenience.

Very sincerely yours,

Wayne B. Nottingham
Assoc. Prof. of Physics

WBN:W