#824 THE INSTITUTE OF PAPER CHEMISTRY

(Electron Microscope)

Project Reports

PROJECT REPORT FORM

PROJECT NO. 824

COOPERATOR Institute

REPORT NO. 3

DATE 10/6/41 (typed 10/17/41)

NOTE BOOK 328

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SIGNED: G. R. Sears

G. R. Sears

At the time the last report was written, we were awaiting the arrival of a new batch of rectifier tubes. Four new tubes were received on July 31 and one of them was installed in the V-52 position. It had been previously noted that when the tube was installed in the manner demonstrated by Mr. Davis, that the anode end of the tube tended to project toward the side of the tank. Since the clearance between the end of the tube and the tank was none too great for adequate insulation, particular attention was paid to the mounting of the anode end of the tube. The anode lead was fastened in the binding post as close to the tube as possible. This held the end of the tube rather near the top of the condenser, but this was not objectionable, since the top of the condenser was at the same potential as the anode of the tube. The cathode end of the tube also lay over the top of the condenser and, unfortunately, there were several screw heads which projected from the top of the condenser and seemed to offer an unnecessary opportunity for sparking between the condenser and the cathode end of the tube. Hence, the cathode leads were fastened more loosely than was recommended by Mr. Davis so that the cathode end of the tube floated at least one-quarter inch above the top of the screw heads. This arrangement seemed to allow sufficient space between the tube and the top of the tank. Since that time approximately 200 hours of operation have been obtained without trouble.

Immediately following the last installation of a rectifier tube on July 31, it was found that the rectifier and filament regulator currents and the negative regulator voltage were not normal. The trouble was due to the failure of the resistor R-26. The fine wire with which the resistor was wound had broken under the sliding contact. A duplicate of this resistor, a 100,000-ohm, 50-watt Ohmite, could not be obtained in the local stores; therefore, two 50,000-ohm, 50-watt IRC resistors were connected in series and used in place of the single resistor. An improvised mounting was necessary, as the two resistors could not be mounted in the same manner as the original resistor. After several adjustments of the sliding contact on one of these resistors, the current and voltage were brought back to their normal value. On August 28, the current and voltage were again abnormal and it was found that one of these resistors had again failed, this time due to sparking between one terminal of the beam current meter and the resistor. The improvised mounting allowed one end of one of the resistors to approach too close to the terminal of the meter. The mounting was changed to eliminate this difficulty and the resistor was replaced. It was impossible to obtain another 50,000-ohm resistor immediately, so the two 50,000-ohm resistors were replaced by a 25,000-ohm and a 75,000-ohm resistor.

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On August 1, the sylphon for the right hand object movement control failed. The failure was apparently caused by too vigorous operation of the screw at the end of its motion. The unidentified small sylphon received in response to our telegraphic order to R.C.A. of July 11 was found to be satisfactory for this replacement. The photographic chamber screen control sylphon, which had been patched with rubber cement on July 21, gave trouble on August 27. The coating of rubber cement was washed off and a piece of rubber dam was cemented around the sylphon. This last improvisation had worked satisfactorily up to the present time. On September 19, the sylphon for the left hand object movement control failed. A replacement was promptly received from R.C.A. in response to a telephone call. While awaiting the arrival of the replacement sylphon an attempt was made to patch the broken sylphon with rubber cement; the location was such that rubber dam could not be used. The attempt was not successful.

The situation with regard to sylphons for the microscope is highly unsatisfactory. R. C. A. is obviously having trouble in obtaining sylphons from the manufacturer; for example, we have been waiting since July 11 for a replacement sylphon for the camera valve. By both wire and letter we have requested Mr. Smith to supply us with the complete specifications of all sylphons so that we may try to get them directly from some manufacturer. As yet we have received no reply. We have sent the incomplete specifications, which are listed in the instruction book for the microscope to the following companies, and asked whether they could supply the sylphons. Clifford Manufacturing Company, Bridgeport Thermostat Company, Chicago Metal Hose Company, and The Fulton-Sylphon Company. Their replies and catalogues indicate that the Fulton-Sylphon Company is the one which supplies R.C.A., the standard sylphons of the other three manufacturers do not fill the specifications for the sylphons needed in the microscope. The sylphons, which the Fulton-Sylphon Company can supply from stock, are not duplicates of those needed in the microscope. However, we have ordered from them the best available items with the expectation that we may be able to modify the end fittings and use them in case of emergency.

The electron gun filament failed and was replaced on the following dates, August 5, August 28, September 9, September 19, and September 27. Several of these replacements were necessary because of the failure of sylphons while the microscope was in operation; the sudden rise in pressure before the filament could be turned off caused serious oxidation and consequent failure. The failure of one or two other filaments was probably hastened by the distortion of the filament necessary in aligning it. This alignment consists in adjusting the filament so that its tip is centered in the opening at the end of the gun.

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Due to the missing sylphon in the camera valve, it is necessary to connect the camera to the main pumping system without preliminary evacuation and there is consequently a considerable rush of air into the main part of the microscope, when the camera chamber is pumped out. This rush of air occasionally blows dust and lint into the apertures of the objective and projector coil pieces. The objective pole piece may be easily removed for cleaning of its aperture. The pole piece in the projector coil cannot be removed without removing the entire coil. The aperture is a Willemite coated disk, which fits into a recess in the top of the pole piece. It is possible to remove this aperture disk through one of the intermediate viewing ports. Originally this could be done only with considerable damage to the Willemite coating. The removal of this aperture disk for cleaning has been facilitated by notching the disk at diametrically opposite points. The tips of a pair of long paper forceps were filed to fit these notches, so that the forceps may be introduced through the intermediate viewing port and the aperture disks lifted out without marring the Willemite surface.

The ionization gage, which we used up to September 19, was a temporary one sent us to replace the original one, which failed shortly after Mr. Davis' first visit. This was replaced by a new gage on September 19. At the same time, a 750-ohm resistor was installed in the R-77 location. We had previously operated without a resistor in this position. The original one was taken out by Mr. Davis during his first visit.

The actual magnifications obtained with several settings of the projector coil current were determined. Specimens of a bacterium, Rhodococcus roseus, were photographed in the electron microscope. Images of the same bacteria were projected onto a ground glass screen by means of an ordinary light microscope affording known magnification and the images were measured. Measurements of the electron microscope photographs then permitted calculation of the magnifications of the electron microscope. The boundaries of the bacteria were not satisfactorily sharp and it was difficult to measure the images accurately. Magnifications are being redetermined using specimens of diatoms, whose images may be much more accurately measured.

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G. R. Sears

Since the preparation of Report One, a blueprinted copy and two printed copies of the Instruction Booklet for the microscope has been received. The first report recorded some of Mr. Davis' suggestions for the preparation of the fine aperture in the objective pole piece. These suggestions should be reconsidered in the light of the section entitled "Replacement of Objective Apertures" which is found on pages 38 - 43 of the Instruction Book. Likewise the tentative procedure for aligning the coils of the microscope should be reconsidered in view of the section entitled "Realignment of the Microscope" which appears on pages 43 and 44 of the instruction book.

From the time of its installation until June 14, the electron microscope worked satisfactorily. During that time, we familiarized ourselves with the operation of the instrument by examining a number of specimens. Among them were specimens prepared from waste sulfite liquor, five-micron wood sections prepared by Dr. Isenberg, sulfite pulp "skin substance" supplied by Dr. Clark, and bacteria of interest to Dr. Appling and Miss Smith. From June 10 to June 13, Dr. C. G. Albert of Edgar Brothers was at the Institute and we examined several samples of clay, calcium carbonate, and calcium silicate. This visit of Dr. Albert's was described in a memo to Mr. Steele of June 25.

At the time that Mr. Davis installed the microscope, the chassis was temporarily grounded by connecting terminal No. 25 of the panel terminal

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board to the ground wire leading up to the G.E.R.S. On June 16, this temporary ground wire was replaced by the electrician and terminal No. 25 of the panel terminal board was connected by a heavy wire leading through the floor chase to the body of the brass valve which controls the cold water supply to the small dark room.

For several days prior to June 16, the beam had flickered badly. On June 15, the flickering became rather severe and during efforts to increase the beam intensity by adjusting the position of the gun filament, it was found that the intensity of the beam failed to increase normally as the beam current was increased. This saturation of the beam current indicated that the voltage was not at normal value. The chassis was opened for inspection but nothing was found wrong. When the instrument was put into operation again, the same behavior was noticed and furthermore it was found that the power amplifier current was higher than normal, that is, it was about 400 milliamperes instead of 300 milliamperes. Sparking was heard, apparently in the oil tank, and thereafter no beam current could be obtained. The power amplifier current was then 450 milliamperes. The chassis was opened again and another general inspection made without the benefit of a wiring diagram since we had not at that time received a copy of the instruction book. No trouble was obvious. Mr. Arthur W. Vance of the R.C.A. Manufacturing Company was called on the telephone. He suggested that the most likely sources of trouble were the special rectifier tubes in the oil tank and the oscillating circuits which supplied energy to the

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filament of one rectifier, to the electron gun, and to the high voltage circuit in the oil tank. He suggested testing the oscillating circuits with a neon lamp, a common indicator of oscillation. Upon testing, it was found that neither the rectifier filament oscillator nor the gun filament oscillator appeared to oscillate with unusual vigor. During the checking of the circuits for a cause for low amplitude of oscillation it was found that the tank coil, L-15, was damaged. This damage was apparently due to careless use of a screw driver when the chassis was opened. Only one turn of the coil was broken and this was repaired by soldering. A nearby resistor, R-10, was rotated slightly to make sure that one terminal was not grounded. When the chassis was closed, it seemed to close in a suspicious fashion and examination showed that this resistor had scraped against the flange to which the top of the chassis is fastened. The leads to the resistor were straightened and rubber stoppers were used to support the top of the chassis about one-half inch from its normally closed position. After these adjustments, the rectifier filament appeared to operate satisfactorily.

One end of the grid condenser, C-54, of the 6V6 oscillator was found to be crimped but not soldered to the appropriate soldering lug at the socket. This connection was soldered.

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When operation of the instrument was attempted after these adjustments, it was found that the high voltage supply was still not operating. The oil tank was opened and the rectifier tubes were inspected. Testing with the high frequency leak tester coil showed that the rectifier V-52 was "gassy". The other rectifier tube, V-53, was found to have been punctured by a spark and contained nearly a cubic centimeter of oil.

Mr. T. A. Smith of the R.C.A. Manufacturing Company was called on the telephone and he agreed to send two new tubes by air mail.

The new rectifier tubes arrived on June 20. They were described in a telegram from Mr. Smith as experimental tubes. It was found that the re-entrant part of the press seals were filled with sulfur. During the installation of these tubes, it was found that the flexible leads were brittle and unusual care was necessary in making the connections to avoid breaking the stranded wire. In spite of this care, the anode lead to the tube in the V-52 position broke about 5/16 of an inch from the end of the sulfur plug. A small brass connector was made to connect the flexible lead to the broken end which projected from the sulfur plug. A heavy copper wire was also fastened to the binding post and so bent as to rest over the broken lead at the plug and limit the rise of the tube when it floated in the oil tank. The purpose of this support was to relieve the improvised connector of the strain of holding the tube against the buoyent force due to the oil. It was found that the most convenient way of installing the tubes was to install the V-53 tube first. The

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thumb screw in the binding post for the anode connection was removed and the tube was slipped past the binding post and then back through the hole in the partition to its normal position. The tension on the leads must be sufficient to prevent the tube from floating when immersed in the oil. The proper tension is difficult to describe but it may be said that when the tension is proper, a reasonable lifting force applied at the middle of the tube does not lift the tube from its rest position by more than a quarter of an inch. Both tubes were mounted so that the small conical seals at which the tubes had been sealed from the vacuum system were down. This minimized the danger of sparking from these tips to the top of the tank. The flexible leads were firmly fastened in the binding posts and the loose ends were wound around the thumb screws in the binding post so as to have no loose ends which would cause trouble by sparking.. New transformer oil was obtained from the Wisconsin Michigan Power Company and the tank was filled so that, when cold, the oil level was about 3/8 of an inch from the top of the tank. When operation of the instrument was again tried, the saturation of the beam current was again noticed. The intensity of the spot on the upper viewing screen increased with the beam current until a value of about 300 microamperes was reached, then the intensity quite suddenly decreased as the filament current to the gun was increased although the beam current remained practically constant. It was then noticed by drawing sparks from the high voltage electrode that the high voltage fell off simultaneously with the beam intensity. It thus appeared that the oscillator and/or the power amplifier were not providing the

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power necessary to maintain the high voltage as the beam current was increased toward the normal operating value. The decrease in the magnitude of the high voltage was great, in fact, when the beam intensity changed to practically zero the voltage also changed to practically zero. Sparking was heard in the oil tank and operation was stopped. The oil tank was opened and the sulfur plug in the anode end of the V-52 tube was found to have partially melted and lumps and filaments of sulfur were found on the bottom of the tank. Furthermore, the flexible lead had broken inside of the sulfur plug and it appeared that the sparking which had been heard was due to the sparking across this gap in the lead. Both tubes were tested with the high frequency coil and both seemed to be hard. The voltage supplied to the filament of the V-52 tube was tested and was found to be 7.4 volts on open circuit and 5.6 volts when the filament was hot. A temporary connection was made to the stub of wire in the anode end of the tube by means of a small alligator clip. The end of the clip was cut off to prevent its projecting too far out of the re-entrant end of the tube. A piece of No. 12 bare copper wire was bent and fastened in the anode binding post so as to support the tube and prevent its floating too high in the oil. The alligator clip was connected to this heavy copper wire by a flexible lead. When the instrument was put into operation again, the same saturation of the beam current was noted and the same failure of the beam intensity was observed. After about ten minutes of testing, sparking was again heard in the oil tank and operation was stopped. Examination showed that the cathode end of the V-52 tube had failed. The ring seal at the end had cracked open and the cathode assembly was loose.

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The other rectifier tube appeared to be in satisfactory condition.

Mr. Smith was called again and our troubles were described. It appeared that our troubles were two-fold: First, failure of the rectifier tubes and second, failure of the oscillator and/or the power amplifier to supply sufficient power to permit operating with a normal beam current. It was agreed that Mr. Davis should return to inspect the instrument and bring with him replacement rectifier tubes.

Mr. Davis arrived on June 26 and brought with him four new rectifier tubes as well as the replacement ionization gage. The apparently good tube in the oil tank was removed and two new tubes were installed. Due to the possibility of the oil in the tank having been contaminated by small amounts of sulfuric acid formed while the sulfur was molten, we had drained the tank and refilled it with transformer oil obtained from the Wisconsin Michigan Power Company. When operation of the microscope was tried, the high voltage behaved as previously described and the same saturation of beam current was noted. Mr. Davis described the effect as due to unloading of the power amplifier or to improper operation of the oscillator and amplifier. All circuits likely to give trouble were checked and appeared to be in good order. During the testing, the resistor R-10, previously mentioned, was examined and following some wiggling to test its mechanical strength, it was found that it was open circuited. The open circuit appeared to be near one end of the coil. There was a sliding contact on the resistor which was not in use. This was moved as near the broken end as possible and the connection was changed from the end to this sliding contact. The resistance was then found to be 17,000 ohms instead of the rated 20,000 ohms. Mr. Davis considered this to be satisfactory. This change appeared to have no effect on the intensity of oscillation and the radio frequency current to the rectifier tube filament appeared to be unchanged, as indicated by the panel meter. No other trouble could be found and the operation of the high voltage circuit was still unsatisfactory. The oil tank was opened and it was found that the V-52 tube was gassy. This was changed and the instrument then operated properly.

It was previously reported that the image was not centered properly over the fluorescent screen or the photographic plate. While Mr. Davis was here, he tried to realign the instrument so as to eliminate this asymmetry. He was unable to do so. Upon reversing the current through the projector coil, it was found that the image moved to the opposite side of the proper position. Mr. Davis then agreed that the fault lay in the projector coil and pole piece and could not be corrected by alignment. He agreed to send a replacement coil, pole piece, and screen assembly.

The replacement projector coil, pole piece, and screen were received on July 7. The replacement was effected as follows: The screws in both bottom and top of the coil in the instrument were removed. The manifold flange opposite the projector coil was opened, as were the flanges just above the specimen chamber. The flange in the auxiliary pump manifold near the specimen air lock was also opened. The corona ring and shield above the gun were removed, the gun filament was disconnected, and the bottom plate of the top casing was removed. With the assistance of Messrs. Nolan and Wink, the entire microscope tube was lifted, the old coil was slipped out, the new one slipped into place, and the tube was carefully lowered back into position with attention to the flanges and sylphons. The connections were remade with care in cleaning the gaskets and flange surfaces. The instrument was aligned and the beam was found to be properly centered over the screen and photographic plate. There was a negligible shift in the image position when the direction of current flow through the projector coil was reversed.

Unfortunately, a fine hair or piece of lint was lodged in the aperture of the projector coil pole piece. An intermediate image port window was removed and an attempt was made to clean the aperture without removing the coil. This proved unsuccessful and the fluorescent coating of the screen was damaged. The coil was removed, the aperture disk was cleaned and recoated by spraying the Willemite solution from a DeDilbis atomizer. The aperture was cleaned and the coil was replaced. Upon realignment, the instrument appeared to be in good working order.

In general, the vacuum in the microscope has been very satisfactory. The ionization gage reading has been between one and three

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microamperes. For several days prior to July 11, the best obtainable pressure was definitely higher than had generally been obtainable but was still usable. On July 11, the pressure reached the upper usable limit of 20 microamperes. The vacuum system was tested for leaks by painting all gaskets and windows with ether and looking for sudden increases in the ionization gage meter reading. The trouble was located in the camera chamber and finally more specifically in the camera valve sylphon. An unsuccessful attempt was made to temporarily repair the leak by coating the inside of the sylphon with rubber cement. The microscope was maintained in operating condition while awaiting the receipt of a new sylphon by the following expedient. Two holes lead into the camera valve chamber, one connects the chamber to the auxiliary pumping system, and one connects the valve chamber with the camera chamber proper. These two holes were temporarily plugged with rubber stoppers. This arrangement necessitated evacuating the camera chamber through the main gate valve by means of a main pumping system. When a photographic plate is to be changed, the gate valve separating the camera chamber from the main system is closed and air is let into the camera system by opening the door of the camera chamber. When the plate is changed, this door is closed and the chamber evacuated by opening the gate valve to the main system. This, of course, greatly increases the pressure in the whole system and the pumping time required to regain normal working pressure is greater than when the auxiliary pumping system is in working order. A replacement sylphon has been ordered but due to mistakes on my part and on the part of the R.C.A. Manufacturing Company, it has not yet been received.

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The pressure in the microscope again became unsatisfactory on July 19. As before, the trouble was traced by painting all joints with ether, and finally the trouble was located in the photographic chamber screen control sylphon. The outside of the sylphon was coated with rubber cement and the leak temporarily plugged while awaiting the receipt of the new sylphon.

Following this last attention to the vacuum system, the microscope operated satisfactorily for several minutes, then a thud was heard, and the instrument trembled as a rectifier tube collapsed in the oil tank. Upon opening the tank, the tube V-53 was found to be completely shattered. The other rectifier tube V-52 was tested with the high frequency coils and it appeared to be in satisfactory condition. The third rectifier tube left by Mr. Davis, the remaining one of the four which he brought with him, was installed and the oil level in the tank was checked. Almost immediately upon being put into operation, the usual symptoms of a bad rectifier tube were observed. The power amplifier current jumped to somewhat more than 400 milliamperes and no beam current could be obtained. Upon opening the tank and inspecting the tubes, the V-52 tube was again found to be gassy.

Mr. Smith of the R.C.A. Manufacturing Company was called again and he agreed to send two more rectifier tubes.

The two new rectifier tubes were received on July 25. They were tested with the high frequency coil and one was installed in the V-52 position.

The oil level in the tank was checked and found to be satisfactory. After installation of this rectifier tube, the main power switch was turned on and the tank allowed to warm up for 20 minutes before the high voltage was applied. After this warm-up period, the tank was completely filled with oil as indicated by the seepage of oil from the vent in the plug in the top of the tank. The voltage control knob was turned to the 30 kilovolt position and the high voltage switch was turned on. The electron gun filament was not turned on. The beam current was normal. After several minutes the voltage was increased to 35 kilovolts. The power amplifier current increased considerably, and the beam current increased but was steady. The voltage was increased to 40 kilovolts and the beam current failed to increase but remained at its previous value of 80 microamperes. The power amplifier current increased to 350 milliamperes for 15 or 20 seconds and then jumped to 420 milliamperes, while the beam current went to zero -- the symptoms of rectifier tube failure. Upon opening the oil tank, the tube in the V-52 position was found to be gassy. The remaining spare tube was installed and both tubes were again tested with the high frequency coil and found to be hard.

The rapidity with which these rectifier tubes failed suggested that perhaps the high voltage system was not working properly and that the voltage applied to these rectifiers might be much greater than normal. The power amplifier circuits seemed to be in satisfactory condition, but the tubes, V-17, 18, 19, 20, 21, 23, and 25 were removed and taken to the

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Valley Radio Distributors for testing in their tube checker. The tubes appeared to be satisfactory. When the tubes were re-installed in the panel, the panel test meter readings were identical with those noted during Mr. Davis' last visit. Despite the fact that there appeared to be no trouble with the power amplifier circuits, an effort was made to talk with Mr. Arthur W. Vance of the R.C.A. Manufacturing Company but he was not available.

Before putting the instrument into operation again, another inspection was given the rectifier tubes in the oil tank. The V-52 rectifier is mounted directly over a condenser in the tank. The anode of the tube is connected to the condenser and is therefore at the same potential as the top plate which covers the condenser. The cathode end of this tube, however, is only a few hundred volts from ground potential. It was thought that the cathode end of the tube was unduly close to the top of this condenser and that end of the tube was raised slightly by loosening the leads at the cathode binding post. They were loosened enough to make the tube's normal position about one-quarter inch higher than usual. The tension in the leads was sufficient, however, to prevent the tube from rising unduly when immersed in the oil. The tank was closed and allowed to warm up with the main power on for 20 minutes before the high voltage circuit was operated. At 30, 35, 40, and 45 kilovolts, the operation, with the gun filament off, seemed satisfactory. The beam current rose to a value of 100 microamperes and the power amplifier current increased normally. At 50 kilovolts the

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beam current failed to increase and the power amplifier current jumped to 400 milliamperes. Upon switching back to 30 kilovolts, operation again appeared normal. Upon repeating the cycle, the improper behavior began at 45 kilovolts instead of the previous 50. Another repetition of the cycle showed the misbehavior to begin at 40 kilovolts. At 30 kilovolts the gun filament was turned on and a beam current of 200 microamperes was obtained. Almost immediately another rectifier tube failed. It was found to be V-52 again.

Upon reviewing our troubles with the rectifier tubes, it was noted that we had thus far had eight tubes fail and six of these have been in the V-52 position.

On July 28, Mr. Smith and Mr. Vance of the R.C.A. Manufacturing Company were talked to simultaneously and told of our trouble. I inquired specifically as to the possibility of the trouble being due to some fault of the instrument other than the rectifier tubes. They agreed that that seems very unlikely and Mr. Vance stated in reply to a query of mine that the power amplifier circuit was so designed that it was practically impossible for it to furnish more than the rated voltage. I gave them what data we had with regard to the voltages and currents supplied to the rectifier filaments. This information had previously been conveyed to them in a letter. It was agreed that there seemed to be no trouble due to improper voltage supply to the rectifier filament. Mr. Smith stated that he would send us another batch of tubes and that they would, in their own laboratory, carry on experiments in an effort to discover the reason for our trouble and that they would from time to time make suggestions as to improvements in operating technique and in the method of mounting the rectifier tubes.

It is planned to partition off the corner of the room immediately around the microscope by means of curtains so that the microscope may be operated without interference from or without causing interference to other users of the room. The curtains are now on hand; but have not yet been mounted.

The enlarger in the microscopic dark room is not satisfactory for enlarging from the plates used in the electron microscope. Hence, an enlarger suited to the use has been obtained for use with the electron microscope.

Notebook 328 is being used only for data relating to maintenance of the microscope. Notebook 336 is being used only for recording data on observations, specimens, and exposures. Exposures are serially numbered regardless of project, file number, etc. A card file lists specimens alphabetically and so provides for rapid reference to all work on a particular type of material, regardless of chronological sequence.

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PAGE May 27 TO June 6
SIGNED G. R. Sears
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ELECTRON MICROSCOPE

The electron microscope was received on May 26. Mr. C. E. Davis of the RCA Manufacturing Company arrived on May 27 for the purpose of installing the instrument. He completed the installation and left the Institute on May 30. Dr. Van den Akker, Dr. Nolan, and the writer assisted in setting up the instrument.

One of the special piers in the optics laboratory was cut down slightly below floor level. A layer of sand was placed on the brick work and the concrete slab which previously formed the top of the pier was laid on this sand layer. Three sponge rubber kneeling pads were cut in half and placed on the concrete slab and the microscope was mounted on this padding.

The instrument was assembled and a vacuum obtained with little more than the usual amount of trouble. During the assembly, the thermocouple gage was broken. Mr. Davis immediately ordered a new one which has not yet arrived. One of the Pirani gages used with the molecular still was substituted temporarily for this thermocouple gage. The system seemed to pump down to a good vacuum rather slowly at first. All the joints were tightened and the usual sources of trouble considered. The pressure seemed to go down when the cooling water to the diffusion pump was turned off and that phenomenon suggested that the oil in the pump might be contaminated with some volatile material. This oil, Distillation Products' Octoil, was replaced by the same manufacturer's Amoil which we happened to have on hand for use

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in the pump of the molecular still. The pressure was still not satisfactory and the diffusion pump was taken apart for examination. It was then found that the inlet was rather well stuffed with paper, which had been put into the pump to support the internal parts during shipping. The removal of this paper solved the trouble and the pressure was satisfactory thereafter.

The ionization gage appeared to work satisfactorily when it was first tried. On the third day of Mr. Davis's visit here, the gage began to give trouble. The space current of the gage was too high and could not be controlled by the rheostat provided for that purpose. This current was controlled by a rheostat in the primary of the transformer which heated the filament of the ionization gage. This rheostat was shunted by a 200-ohm resistor. When this resistor was removed, the rheostat appeared to be able to control the current satisfactorily. The morning after Mr. Davis left, the gage failed to operate and test showed that the filament of the gage had burned out. It therefore appeared that the original trouble with the gage was due to some defect in the gage itself and not to the controlling circuit. Dr. Van den Akker wrote to the RCA Manufacturing Company requesting a replacement for this gage. It has not been received.

Mr. Davis said that the instruction book for use with the instrument was in process of being printed and would be sent to us as soon as it was received. He also agreed to send us a large scale wiring diagram of the electrical circuit. The following are miscellaneous comments and suggestions made by Mr. Davis.

The fluorescent screens are made by spraying a solution of willemite, at a concentration of one pound per gallon, onto the appropriate metal surfaces. For some reason the small screens may be sprayed by means of a De Vilbis atomizer, but the large fluorescent viewing screen must be sprayed with a spray gun at considerable pressure. The smaller screens may darken considerably with age and, in fact, may appear almost black in ordinary light, yet they are satisfactory as long as the fluorescent spots are satisfactorily visible. The two small screens undergo a much more intense bombardment by the electron beam than does the large viewing screen, hence their more rapid deterioration.

The filament of the electron gun is made of five-mil tungsten wire. It was suggested that we might wish to replace the filaments ourselves after the stock of spares which is supplied with the instrument is exhausted.

The fine aperture in the pole piece of the objective coil is a 1-mil diameter hole in a disc of copper six mils thick. This aperture is made in the following way: The disc of copper is laid on a smooth hard surface and is dented in the center by means of a specially sharpened needle. This needle is usually an ordinary sewing needle but should be of good steel and the point should be honed until the diameter of the needle at a distance of about four mils from the tip is of the order of two or three mils. If the needle is not so sharpened, the dent made in the foil or copper sheet will be so broad that it will not etch properly in the following treatment. The depth of this dent in the surface should be approximately

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three-quarters of the thickness of the copper sheet. After this denting process, the disk of copper is laid in a solution of nitric acid and allowed to react until enough copper has dissolved to form a fine hole under the dented spot. The treatment should be stopped when this hole is about one mil in diameter. The hole should be smooth and round, not necessarily exactly circular, but oval rather than egg-shaped. It should not have a serrated edge or have any star-like points. When this condition is reached, the disc is washed thoroughly in distilled water. In this process of preparing the aperture, it is important that the needle not puncture the sheet but merely dent it. If the sheet is punctured, the hole is generally not satisfactorily round and smooth, and is usually much too large. The disk thus prepared must be mounted axially in the pole piece. A special brass cone, is provided for aligning the aperture in the pole piece. The aperture is carried in a special brass housing which may be moved radially by means of four screws. The pole piece is placed on the brass cone and the aperture viewed by transmitted light under low power magnification. The pole piece is rotated on the cone and the four adjusting screws turned until the aperture does not appear to move as the pole piece is rotated. Mr. Davis recommended the use of a special microscope which would permit one to view the pole piece from the bottom. There appears to be no reason why an ordinary microscope cannot be used and mounted on a special stand above the pole piece and the aperture viewed from above with the condenser of the microscope removed. Mr. Davis was not sure of the

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prices for these apertures when obtained from the RCA Manufacturing Company, but he remembered roughly that the charge for a new pole piece and aperture was $95 and that upon return of the old pole piece, a credit of $77 was allowed. In other words a new aperture put in by RCA costs about $18. There appears to be no reason why we cannot take care of such a replacement without any great trouble. The aperture must be changed occasionally for several reasons: it may become plugged by having something drop upon it from above; or its edges may become dirty after continued use due to the decomposition of organic vapors in the microscope. Even though the aperture is not plugged, the dirtying due to decomposition of organic vapors is undesirable as it has a deleterious effect on the resolving power of the microscope.

Mr. Davis mentioned that picein wax which is used in sealing the thermocouple gage to the metal diffusion pump is difficult to obtain. They obtained their supply from the S. and G. Rubber Company Incorporated, 15 East 22nd Street, New York. Any of the usual vacuum waxes should be satisfactory.

Mr. Davis also volunteered the following information as to the RCA Manufacturing Company organization: Mr. T. A. Smith and Mr. Henry Rhea of the sales department are familiar with the microscope. Mr. Rhea spends most of his time demonstrating the microscope at the plant. When detailed information is wanted quickly on the microscope proper, that is, on the magnetic focusing system, Mr. James Hillier is the designer and the one with whom to talk. Mr. Arthur W. Vance designed the electrical circuit and is the one to consult on information along that line. If replacement parts are needed in a hurry, the order should be addressed to Emergency Service, RCA Manufacturing Company, Camden, New Jersey and the part number should be specified. The office hours of this service are from 8:00 a.m. until 11:00 p.m. daily except Sunday, when the hours are 9:00 a.m. to 6:00 p.m. This service should be used only in case of emergency and when it is used, the shipment is made within a few hours of receipt of the telephone or telegraphic order.

While Mr. Davis was still here, it was noticed that the overload relay in the microscope did not operate properly, and he adjusted it. The trouble appeared to be due to the unusually stiff hinge in the relay armature and to the stiff pigtail which connected it to the terminal of the relay.

When the microscope is newly assembled, it is sometimes difficult to align the three coils and to get the beam to pass through the required apertures because of the fineness of the aperture in the objective coil. In such a case, it is convenient to remove the pole piece of the objective coil so as to have a larger aperture for the preliminary focusing. When the coils have once been aligned, it is usually not difficult to relocate the beam if it should be lost temporarily, without removing the pole piece. Careful alignment of the system is important since it not only makes for convenient observation and photography but is necessary to obtain the best resolving power of the instrument. If the alignment is not good, the image on the fluorescent screen moves disagreeably when the magnification is changed so that the specimen must be repositioned after each change in magnification. If the alignment is satisfactory, the image rotates but its center does not move laterally. Since Mr. Davis left, the following procedure has been evolved for aligning the coils. This procedure may not be according to the recommended practice but until the arrival of the instruction book it may be useful. It is as follows:

The image at the focal point of the objective coil changes size when the coarse focusing adjustment is turned. The spot is largest when the coarse focusing control is turned in the clockwise direction as far as possible, that is, with the maximum current through the coil, and the spot is smallest when the coil is turned in the counterclockwise direction as far as possible, that is, when the current through the coil is the least. It seems that this spot should not move but should merely expand or contract concentrically when the coarse focusing adjustment is turned. With the coarse focusing adjustment at its farthest clockwise position, the large spot is centered on the aperture in the fluorescent screen in the focal plane of the objective coil by adjustment of the position of the objective coil. If the alignment of the condenser coil is not correct, the spot will become smaller and move to one side or the other as the coarse focusing adjustment is turned in the counterclockwise direction. With the coarse adjustment in its extreme counterclockwise position, the spot is brought back to a position over the aperture by manipulation of the condenser coil. This second adjustment requires readjustment of the objective coil and so on.

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This cycle of adjustments must be repeated a number of times before the fluorescent spot contracts concentrically about the aperture in the fluorescent screen. When this has been done as carefully as possible, the image on the viewing screen in the focal plane of the projector coil moves very little and the alignment appears to be satisfactory. During these manipulations it is necessary to adjust the position of the electron gun in order to keep the spot at uniform brightness. When adjustments of either objective or condenser coil are made, care must be taken not to let the spot fade out of sight; when the spot fades, the adjustment must be stopped and the gun positioned for maximum intensity of the spot before the manipulation of condenser or objective coil is completed. The alignment of the condenser and objective coil is not entirely independent of the position of the gun and since it is necessary to make rather frequent adjustments of the gun to keep the spot at maximum intensity, it is necessary occasionally to readjust the alignment of the condenser and objective coil, although the misalignment due to adjustment of the gun is not serious in most cases.

It was noted that the image on the viewing screen in the focal plane of the projector coil was not centered over the photographic plate and it appeared to be impossible to align the condenser and objective coil so that the final image would be centered over the photographic plate. This matter was called to the attention of Mr. T. A. Smith in a letter of June 6. At the same time, his attention was called to the fact that an annoying amount of oil leaked from the tank by capillary action and dripped or ran down the front panel, as well as over the cables connecting the oil tank to the chassis.

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The image intensity increases as the voltage applied to the gun is increased from 25,000 to 60,000 volts. The increase in intensity is most rapid through the lower part of the voltage range. Therefore, in general, it seems suitable to use a voltage of 55,000. This is below the maximum and will be less likely to overload the rectifier tubes than would the maximum voltage of 60,000, and the intensity is satisfactory.

Miss Evelyn Kregel is now familiar with the instrument and is able to use it without assistance. Mr. Dearth has spent several half days with the instrument and will shortly be able to use it without assistance.

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