
Early Television Museum


LIARD


PEN
ODAY
2.00-5.00
2.00


Schenectady, New York. The first
TV drama, the Queen's Messen-
ger, was produced in September
of that year by GE. This set was
probably made by GE for displays
at its dealers in the 50s. It was
made by molding parts from an
original set.


Raytheon
Baird Kit Copy
Hollis Baird Receiver


THE
MERCIE
CO.


THE
MERCIER
CO.


Western Vacuum
Owen Television Receiver


Mechanical TV Sets of the 20s and 30s
What Things Cost in 1930
Car: $525
Gasoline: 20 cents/gal
Home: $7,150
Bread: 8 cents/loaf
Milk: 50 cents/gal
Postage Stamp: 2 cents
Stock Market: 165
Average Annual Salary: $1,600
Mechanical TV: How it works
(Courtesy of IMTV)


1939 Television Kit Chassis
This is a pre-war kit chassis that was built by an RCA tube engineer in 1939. It tunes two channels, using some of the same parts as the RCA TRK series. The design came from the Sickles company, which made the IF transformers.
Philco Television Oscilloscope
Introduced by Philco in 1939 specifically for television servicing.


TELEVISION


1946-52
European Sets


Saba P 1028 H


Remembrance


FIRST TIME at DWIGA
Full Color Television

COLOR TV IS HERE

Start of Regular Commercial Schedule To Be Celebrated With Special Show

PRINCIPALS IN C.B.S. FIRST COMMERCIAL COLOR TELECAST TONIGHT

ANONYMOUS

U. S. COLOR SHOW WILL BEGIN NOV. 21

COLOR TELEVISION BY R.C.A. IS SHOWN

Large-Screen Demonstration in Theatre Staged Here by Invited Audiences

CBS Field Sequential

Color Television

1951

Now Available! CBS-Columbia Glorious Color Television

FIRST TIME at DAVEGA

Full Color Television

CBS-Columbia

Color Television Receivers

Use The Only Approved Color System

Enjoy The Thrills & Excitement of FOOTBALL IN FULL COLOR

9 MAJOR COLLEGE GAMES TELECAST IN FULL COLOR

FIRST GAME—TOMORROW

PENNSYLVANIA vs CALIFORNIA

• Not "Next Year" - Not "Tomorrow" - But TODAY! All You Do Is Flick A Switch To Enjoy...

PROGRAMS IN FULL COLOR... & ALL REGULAR BLACK & WHITE PROGRAMS

Special Trade-in Offer!

Davega Will Give A Big Allowance For Your Trade-in TV, Radio, or Phono...The Value Of Your Trade-in May Mean

NO CASH DOWN ★ 78 WEEKS TO PAY

FOR FURTHER INFORMATION — CALL WA 4-4848

DAVEGA

• BRONX...31 EAST FORDHAM ROAD

• BROOKLYN...300 FULTON ST.

• QUEENS...165-24 JAMAICA AVE.

ARTICLES & ADS COURTESY

STEVE DICHTER

HOLLYWOOD, CA.


Rembrandt
Power King
TV


CHANGE BLACK AND WHITE TV TO COLOR TV
With This
COLOR-TV
Filter
"SO PLEASING TO THE EYE"
"SEE"
• YOUR FAVORITE PROGRAMS IN NATURAL COLOR
• BLUE SKIES
• GREEN GRASS
• CAN ALSO BE USED ON A COLOR TV SET FOR A REAL LIVE TRUE PICTURE
• CUT TO SIZE OF ANY TV GLASS FRONT
• SLIDE INTO TOP OF GLASS FRAME OUTSIDE TV OR TAPE ON OUTSIDE OF GLASS
— RELAX AND ENJOY —
COLOR BY EASTMON
"TRY IT NOW"
"BUY IT NOW"
© EASTMON Co.


magic
carpet antenna


JERROLD
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carpet* antenna
The Magic Carpet to Fine TV and FM Reception
THE FLAT, FLEXIBLE PRINTED CIRCUIT ANTENNA


JERROLD magic carpet* antenna
• No Need For Costly Rooftop Antennas in Most Areas
• No Need For Unsightly "Rabbit-Ears"
• Satisfaction Guaranteed or Your Money Back
JERROLD ELECTRONICS CORPORATION • Philadelphia 32, Pa.
EASILY INSTALLED IN HOME OR APARTMENT
Note: For Best Reception Install at Highest Convenient Point
IN THE ATTIC
GARAGE OR UTILITY ROOM CEILING
UNDER THE RUG
JERROLD magic carpet* antenna


Color Television
W·G·S·F TV. 31


Color Television
W·G·S·F TV. 31


Color Television
W·G·S·F TV. 31


WGSF
TELEVISION
31
NEWARK
W·G·S·F TV. 31
TV·13


WGSF
TELEVISION
31
NEWARK
W·G·S·F TV. 31
TV•13


WGSF
Television
RCA TK-31 Field Camera
This camera was introduced in 1950 and was the standard field camera for almost a decade. Some stations also used them as studio cameras.


RCA TT-25AL 25kw
Amplifier
Two of these amplifiers were used by WTVN-TV to boost the visual and aural output power. With a maximum visual power of 25kw, the effective radiated power of the station was 100kw due to the gain of the transmitting antenna.


TV abc 13
General Electric PC-4 Camera
This studio camera uses the Image Orthicon, the second generation of camera tubes. It was made around 1950 and used originally in a TV station in Louisville, KY. It was then moved to a station in Albany, NY, where it was used for remote pickups from a bowling alley.
HOUSTON FEARLESS


WGSF
31
TELEVISION
NEWARK


2
8
10


RCA TP-16
Film Chain
Projector
American Radio Institute


RCA TM-2B Monitor
Western Electric Video and Waveform Monitors


Diamond Power
Unitesage Image
Dissector Camera and
Monitor
Dage Industrial
Cameras

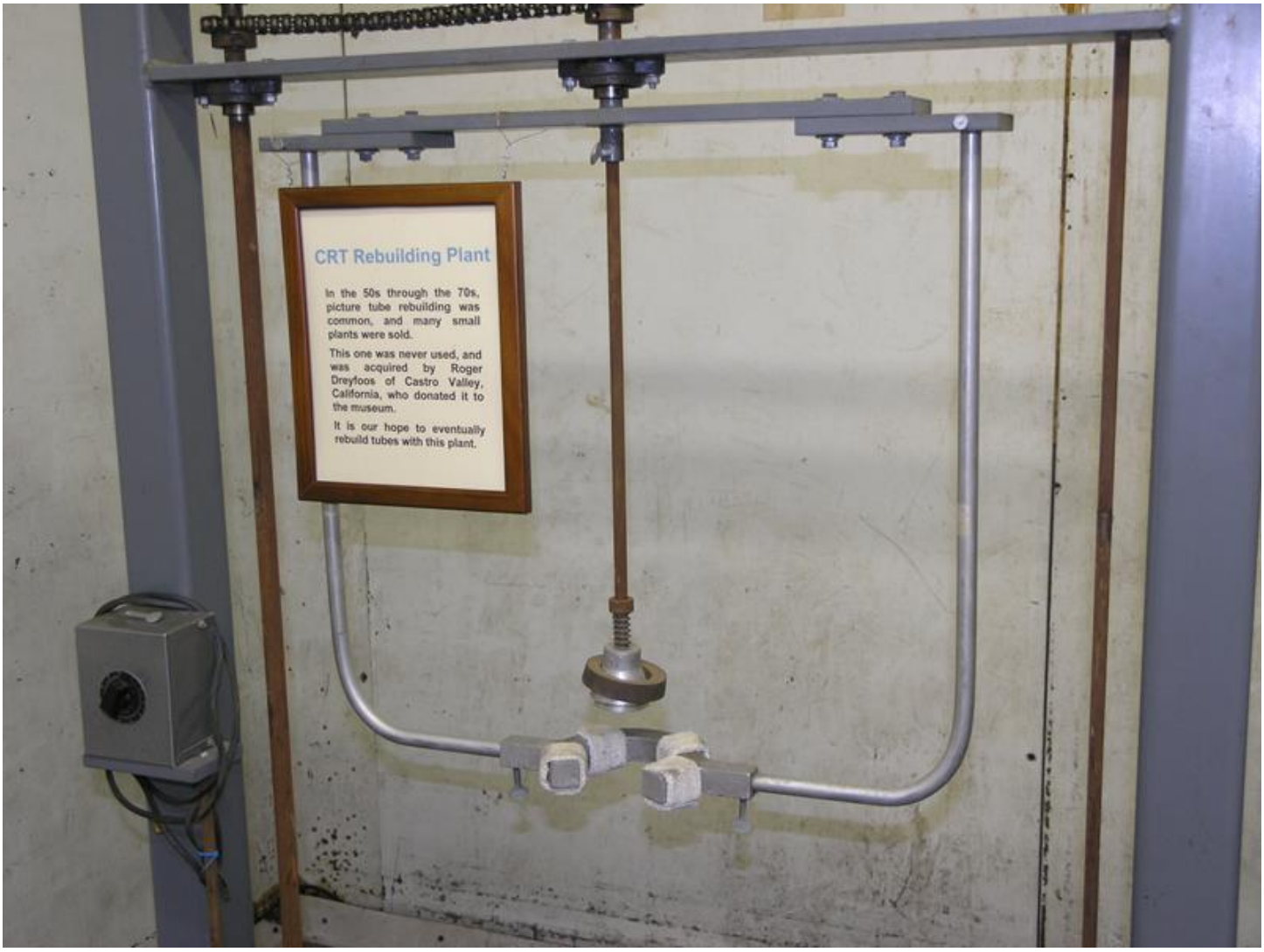

RCA TM-5
Master Monitor
RCA TK-31 Field
Camera Contol
Unit
Camera Power
Supply from W2XJT


RCA TK-31 Field Camera Contol Unit
Camera Power Supply from W2XJT
General Electric TM-5-A Studio Monitor
General Electric PC-2 Film and Slide Camera


PINKPLUS
R-13


SPARTON
15" color
Yoke, Knobs
RCA VICTOR

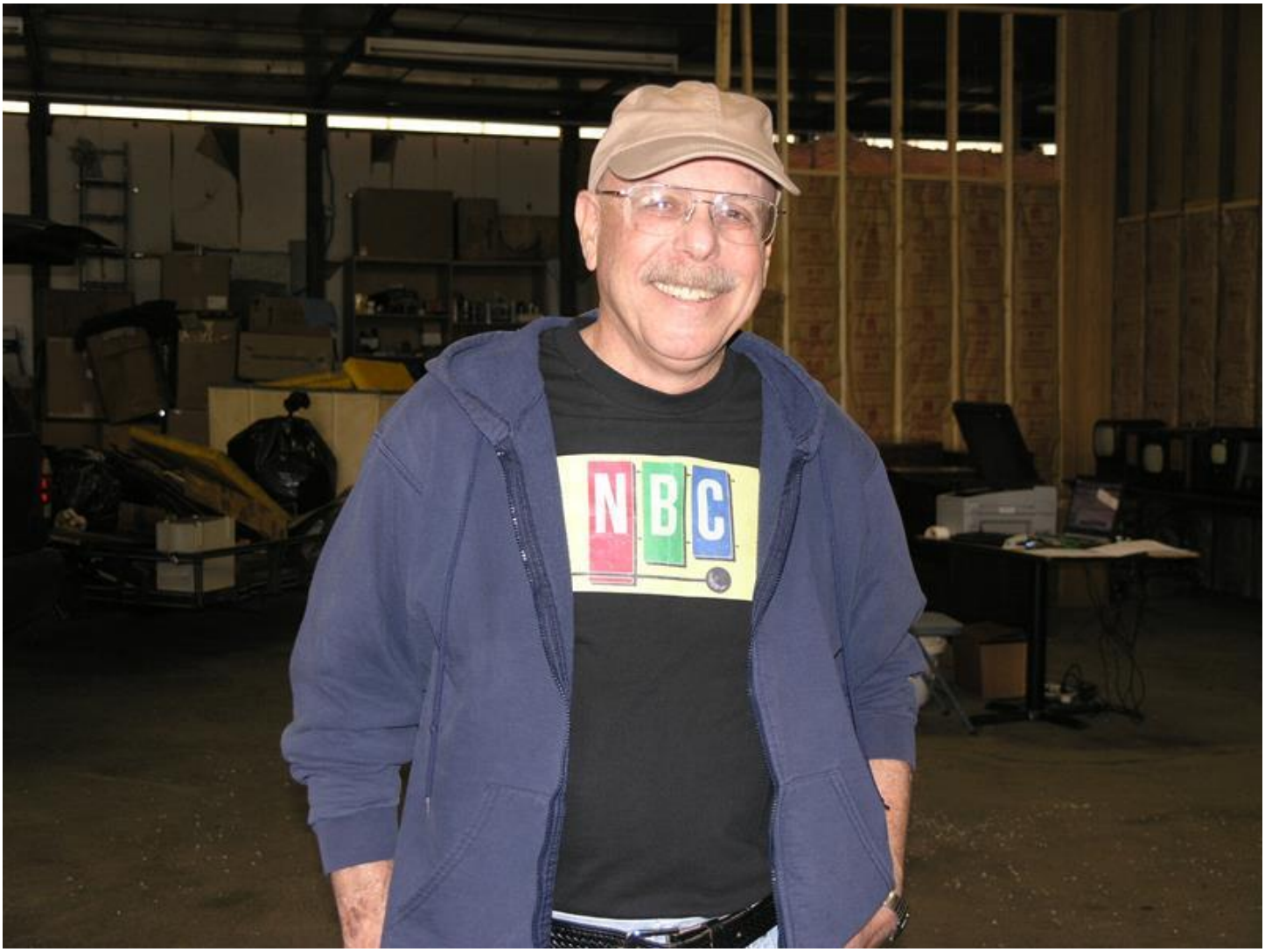

GILDAN


CRT Rebuilding Plant
In the 50s through the 70s, picture tube rebuilding was common, and many small plants were sold.
This one was never used, and was acquired by Roger Dreyfoos of Castro Valley, California, who donated it to the museum.
It is our hope to eventually rebuild tubes with this plant.


THIS SIDE UP
LASS
HANDLE WITH CARE


RCA


RCA


NBC


PRIORITY
MAIL


FRAGILE
THIS SIDE UP
GILDAN

INSTALLATION AND OPERATING INSTRUCTIONS

For

Col-R-Tel Converter

COLOR CONVERTER, Inc.

COLUMBIA CITY, INDIANA

De Var Electronics Co.

COLORDAPTOR

COLOR TV CONVERTER

Although rapid advances are being made in commercial color TV, as yet most circuits are very complex requiring expensive and difficult to obtain components such as the tri-color kinescope. For the experimenter interested in color TV, the Colordaptor offers a method of obtaining good color TV from present black and white receivers at a minimum of expense and complexity.

The Colordaptor system employs a simple two tube circuit and a rotating color wheel to convert any black and white, direct view or projection TV to full color operation.

The Colordaptor decoder employing only seven tubes is the heart of the system. This new and ingenious circuit converts the NTSC compatible dot sequential color signal, now standard in the United States, into a field sequential signal. The field sequential signal is supplied to the black and white picture tube and, when viewed through the rotating color wheel, a full color picture results.

The Colordaptor can be built from parts most experimenters have on hand. The tubes are standard receiving types and all the coils may be home-wound by the experimenter. The Colordaptor decoder has undergone extensive development work to simplify all circuits and reduce critical adjustments. The completed system has only two color adjustments, hue and saturation. An r.f. signal generator and a standard volt-ohmeter are the only test instruments required for alignment of the system.

Figure 1 shows the complete Colordaptor system. The installation shows the color wheel mounted on a removable unit which is placed on the top of the TV set. The Colordaptor chassis may be permanently attached to the rear of the set since when left connected it does not affect normal black and white reception. The color wheel may be removed when color reception is not desired.

There have been numerous articles in radio and television publications describing the NTSC compatible color television signal. The reader should be reasonably familiar with the basic concepts embodied in the NTSC signal. As is explained in these articles, the color signal is transmitted as a sub-carrier at 3.58 mc. The color information is separated into two parts, hue and saturation. The hue is the color, that is red versus yellow, and the saturation is the depth of color, that is bright red versus pink. At the color receiver the hue of the picture is determined by the phase of the received color sub-carrier and the saturation is determined by the amplitude of this signal. The reference phase, which is transmitted during the horizontal retrace as an eight cycle burst, establishes a reference for the phase information.

As is shown in Figure 2, a certain phase angle corresponds to each of the primary colors. That is, 90° from the reference phase is the red information angle, 180° the blue, and 270° the green. In the conventional color TV set, two synchronous demodulators are used which measure the amplitudes of two phases 90° apart. The most common system now in use is the R and B system which demodulates along the 90° and 180° directions. The third color G is obtained by adding these two signals in the proper proportion. Hence all these systems have the common characteristic that three are three color signals being produced at all times.

However, in the Colordaptor system only one signal at a time is required. When the red filter is in front of the TV tube, the Colordaptor demodulates along the 90° phase, for blue it switches to 180° and for green it switches to 270°. This switching operation is continued automatically from red to blue to green and the rotation of the color wheel is locked in with this switching operation. Consequently, a complete red picture is followed by a complete blue picture, and finally a complete green picture. The switch operates at 60 cps so that a set of three color pictures is produced each 1/20 second. The eye then superimposes these three colored pictures to give the full color effect.

Operation of the Colordaptor

The block diagram of the Colordaptor is shown in Figure 3. The video is taken off at the second detector and, after going through a stage of preamplification in the set, is fed into a high gain chroma amplifier, V1. This stage is designed to discriminate against both the low frequency black and white video signal and the high frequency 4.5 mc sound channel. The output of the chroma amplifier is fed to the demodulator, V2, and the burst gate, V3A. The burst gate is normally biased off until the horizontal synch. pulse drives it into conduction. This occurs towards the end of the horizontal flyback which is exactly when the 8 cycles of 3.58 mc reference occurs. Thus the burst gate output consists of bursts of 3.58 mc reference signal. The crystal filter with associated V3B drive tube, converts these bursts into c.w. 3.58 mc r.f. reference.

The reference phase shift network then supplies exactly the correct delay so that reference phases for the three colors, as shown in Figure 2, are generated and fed into the tritch (tri-stable switch). The tritch, made up of triodes V4A, B and V5A, is essentially a three position rotary switch 'rotating' at 20 cps. It is triggered among its three stable conditions by the vertical synch. pulse via V5B. The output of the tritch is then 3.58 mc which has a phase of alternately 90°, 180°, and 270° relative to the reference signal. After amplification in the reference amplifiers V6 and limiting in diodes D1 and D2, the tritched reference is applied to the demodulator, V2.

The output of the demodulator is then amplified in V11 and applied to the cathode-ray tube grid (R and W video on the cathode) or cathode (R and W video on the grid).

The delay line is added in the black and white video circuit so that the black and white signal and the color signal arrive at the picture tube at the same time. Connections are made to the vertical and horizontal sweep circuits to provide synchronizing signals for the Colordaptor.

The color wheel and associated drive mechanism includes a small magnetic pickup which gives a voltage pulse once for each set of red, blue and green filters. This synchronizing pulse is compared with the plate wave form of the blue tritch triode and the phase difference detected by V7.

The resulting control signal is applied to the control tube, V8, which in turn controls the motor speed through the control transformer.

Constructing the Colordaptor

The Colordaptor chassis layout is shown in Figure 4, and parts list in Figure 5. A 3 x 12 x 3 chassis is large enough to hold the entire system including power supply and synchronizer.

A suggested procedure for construction is to first locate all socket, transformer and trimmer condenser holes. After these holes are all cleaned and drilled, mount all the large components in place. Wire the tube heater leads using the chassis as a common ground. The heater lead should be bypassed to ground at V6 with a 0.01 mfd capacitor. Using the points run a B+ bus as in Figure 4.

Since most of the components associated with V4 and V5 are not critical as to wire length it is advisable to mount them on a terminal board. This terminal board layout is shown in Figure 6. Then mount the terminal board as shown in Figure 4.

Mount and wire in place all inductors and trimmers. These should be placed approximately as shown in Figure 4. The windings and dimensions of the coils are given in Figure 7. It is important that L7, L8 and L9 are well separated, since oscillation is possible in the high gain reference amplifier. For those not wishing to wind their own coils, special coils designed for the Colordaptor are available in kit form as listed in the attached price list.

When wiring the crystal diodes into the circuit great care must be taken not to overheat the diode. It is best to hold the diode with a pair of long nosed pliers on the lead being soldered. The diode end marked "G" or having a colored dot or band is the cathode which corresponds to the bar side of the schematic symbol.

If external controls are desired for the Colordaptor the "color gain" control R9 and the "reference phase" control C21 may be located on the TV set front panel. The connection to R9 should be kept away from any high voltage pulses, but otherwise is not critical for length. The connection to C21 may be run through a shielded cable for a length up to about 4 feet. The additional capacity of the cable reduces the amount of capacity which must then be added as the reference control. A 100 mmf variable capacitor should be satisfactory.

The connections which attach the Colordaptor to the TV set are shown in Figure 8. All the connections except the twisted pair (wires B and C) and the color signal connection to the C-R tube may be run in a cable. The vertical synch. pulse required is taken from the grid of the vertical output tube of the TV set through a 10-150 mmf padder capacitor. This is a negative pulse of about -10 to -30 volts.

The horizontal synch. pulse is taken from the plate of the horizontal output tube. This pulse has a positive amplitude of about 3000 to 5000 volts. This is reduced in amplitude by a divider network to approximately 30 volts. An alternate connection is to wind about 10 turns of wire about the horizontal output transformer core. One side of this winding is grounded at the TV set and the other connected directly to the Colordaptor.

The chroma signal for Colordaptor is amplified by the 6CB6 V1. The power for V1 may be obtained either from the Colordaptor or preferably from the

TV set. The addition of V5 to the set makes it possible for the Colordaptor system to operate from any standard TV since the preamplifier may be adjusted to compensate for insufficient i.f. amplifier bandwidth. The chroma preamplifier (C26) can be mounted on the TV chassis, or on a bracket near the video detector. The trimmer should be mounted in such a manner that it is accessible for tuning when the chroma amplifiers are aligned.

A delay line shown in Figure 9 is added to the video amplifier of the TV set in the plate circuit of the output video amplifier as shown in Figure 8. This delay line has a delay of about 1.3 usec and an impedance of 5 K ohms. The delay line winding should be made about 8-1/2" long and after the set is operating its length can be trimmed to accurately align the color and black and white pictures. The delay line is also available from Colordaptor (K-1).

In addition vertical and horizontal retrace blanking signals are added depending on the present method of connection of the black and white video to the picture tube. The proper retrace connections are shown in Figure 10a and b. The connections in Figure 10a apply when the video is on the cathode of the kinescope, and Figure 10b when the video is on the grid. The color signal is applied to the grid in the first case and the cathode in the second.

Color Wheel

The color wheel consists of six specially curved color filters mounted on a frame of sheet aluminum or plexiglass. This wheel gives two complete color pictures per rotation and therefore operates at a speed of 600 revolutions per minute. The six filter segments consist of two each of the three primary colors, red, blue and green. The colors and densities of these filters must be carefully selected such that white light when viewed through the rotating filter wheel appears white. Color filter materials having these properties is available from Colordaptor (K-10, 12 or 13).

The color wheel layout is obtained by redrawing Figure 11 to full scale. The color wheel radius is found by measuring the distance from the drive hub (which is located directly above the left edge of the picture) to the lower right hand corner of the picture tube. After determining the color wheel diameter, a full size cardboard template of the color filter segment can be made. This template may then be used to cut out the color filter segments and to lay out the supporting web. The supporting web which has spokes approximately an inch wide is constructed of sheet aluminum, masonite, or other light material. The color filter segments are attached to the web with transparent tape or cement. It is important that the color filters are arranged such that they pass the picture tube in red - blue - green sequence.

Another method of color wheel construction is to sandwich the color filter segments between two heavy sheets of transparent celluloid or similar clear plastic. Duratone, or clear airplane cement, is applied along the edges of the color filter segments. The assembly is then held under pressure until the cement is dry. This construction method protects the filters and offers less wind resistance.

Color wheels for up to 17" TV sets can be made from heavy duty celluloid color filter material available from Colordaptor. For smaller sets, these wheels will be self-supporting and for larger sets three wire ribs will make the wheel self-supporting. In general, the wheel operates much better if placed in a housing cabinet which is easily made from plywood or fiber-

board. This cuts down the air friction which in turn reduces the motor load, reduces the loading on the wheel, improves the control characteristics and eliminates the noise generated by the wheel.

A typical color wheel drive mechanism is shown in Figure 12. The motor is bolted to a plywood or fibreboard backplate and a small pulley attached to the motor shaft by a setscrew. The color wheel is mounted on a second pulley which in turn rotates on a stationary shaft fastened to the backplate. This pulley is made from brass, aluminum or bakelite and has pressed into it a bushing bearing. On the back face of the pulley are mounted two soft iron pole pieces next to which the synchronizing pickup coil is mounted. The color wheel is attached to the front face of the pulley. The two pulleys are connected with a rubber belt. The pulley diameter ratio must be selected such as to give a speed of slightly greater than 600 rpm (with the color wheel attached). Stops must be fashioned on the shaft to prevent any front to back motion of the color wheel hub. This is necessary to maintain constant spacing between the synch. pickup coil and the rotating pole pieces.

The Colordaptor system is also adaptable to a projection type TV receiver. This is simple conversion since it requires a color wheel only large enough to cover the lens of the projection unit. It is suggested that the color wheel be composed of three pie shaped segments and the wheel driven at 1200 rpm in which case the synchronizer pickup should give one pulse per revolution of the wheel.

The color wheel drive motor should have about 1/70 HP for projection and 7" TV sets, 1/30 HP for 10 to 17", and 1/15 HP for 19 to 21" TV sets. An induction type motor is preferred such as a two phase capacitor or shaded pole motor. A series universal motor may also be employed, but the AC supply to the motor must be adequately filtered to prevent TV interference.

The color wheel drive motor speed is controlled by V7 and V8 to synchronize the color wheel with the TV picture. The synch. pickup coil, shown in Figure 12, generates a pulse which is compared with a switching signal from the plate of V6B in the phase detector V7A. The voltage on the grid of V7B is about -2 to -4 volts when the pickup coil signal and V6B signal are both positive at the same time. The voltage goes to zero when the two signals are out of phase. The signal is amplified in V7B and applied to V8 which acts as a grid controlled rectifier and saturates the control transformer, T2, which in turn reduces the voltage drop in the transformer secondary winding. The control transformer, T2, is a Stancor A3053, universal output transformer. The two plate leads are connected as a primary and the voice coil windings connected in series with the motor. Standard power transformers have also been used by connecting the high voltage winding across V8 and using the filament windings in series or parallel as a control winding.

The synchronizer pickup coil is constructed from a surplus 24 VDC relay by disassembling the relay and removing the relay contacts. The relay is then modified by bending the relay side support at a right angle as in Figure 13. An alnico magnet, such as is employed in FM speakers, is then fastened to the relay using an aluminum or brass clamp. The pickup coil is then mounted so that the rotating iron pole pieces on the color wheel drive pass across the face of the pickup coil, complete the magnetic circuit and thus induce a signal voltage in the coil. Alternately an earphone magnet may be used in place of the modified relay. The location of the two rotating pole pieces is shown in Figure 12. The synch. pickup coil should give a voltage of at least 5 volts rms when the color wheel is rotating at 600 RPM. The addition of the synch. pickup coil to the color wheel drive mechanism completes the construction of the Colordaptor system.

Alignment and Adjustment

Before beginning adjustments carefully recheck all wiring connections against the schematic. Check the B+ voltage from the power supply after the Colorsyncator has been on for about three minutes. This voltage is set to between 300 to 325 volts by adjusting the power supply series resistance R22.

The next adjustment, alignment of the chroma amplifiers, requires a signal generator calibrated to cover the range 2.5 to 5 mc and a detector. The detector may be a high frequency probe on a vacuum tube voltmeter or simply a crystal diode and a multimeter connected as in Figure 14.

Attach the signal generator output to the grid of V1 and the detector across L4. Set the signal generator to 3.5 mc and first adjust C8 and then C7 for maximum response. Now set the signal generator to 4.5 mc and tune the sound trap T4, for minimum response. As the signal generator frequency is varied a response curve as shown in Figure 15 should result. Some retuning of C7 and C8 may be necessary to obtain this response. If other curves are obtained retain the value of R5 to flatten the response. Now leaving the detector across L4 attach signal generator input to the TV video detector, so that the signal goes through the TV set preamp. V3. Set C1 at about half capacity. The longer the twisted pair length the lower will be the final value of C1. Set the signal generator at 4.5 mc and tune the sound trap T2 for minimum response. Set the signal generator at 4.5 mc and adjust C5 and the ceramic trimmer C10 for maximum response. Then tune signal generator to 3.5 mc and adjust C1 for maximum response. Repeat these adjustments until the response curve (Figure 15) has sharply peaked gain at 4 mc and is designed to compensate for reduced IF and video bandwidth of many sets. For TV sets having wide band IF stages reduce the value of R6 and shunt the peaking coil L16 with a suitable resistance to obtain flat response from 3 to 4.1 mc. As a final check readjust the sound trap T2 and C5 for minimum response at 4.5 mc. This completes the alignment of the chroma amplifier circuits.

The reference channel adjustment is begun by connecting the signal generator to the grid of V10 and a voltmeter to the test point, Plate R4. Tune the signal generator to 3.58 mc and adjust C10 for maximum response keeping the test point voltage below 1 volts by reducing the signal generator output. Move the signal generator to the grid of V14 and with the signal generator at 3.58 mc repeat the above procedure for adjusting C13.

The reference channel phase trimmer is now checked for proper operation. This is most easily done by connecting an oscilloscope, synchronized by the TV set vertical sweep, pulse, to each of the trimmer plates. When properly operating the waveforms of Figure 17 are obtained. If an oscilloscope is not available, connect a voltmeter between B+ and each of the trimmer plates, in turn. All plates should indicate a voltage of about -20 volts with respect to B+.

If the trimmer is not functioning as above, disconnect the vertical sync. pulse from the TV set. Cycle the trimmer by momentarily shorting to ground each of the grids, V14, V16, and V18 in sequence. Then momentarily short the V14 grid to ground. Now the V18 plate should be 20 volts less than B+ and the other two plates should be near B+. Similarly shorting the V16 grid should lower the V14 plate voltage and raise the other two plates to B+. The cycle is finished by shorting the V14 grid to ground which restores the original condition of the V14 plate to 20 volts less than B+ and the other two plates at B+. If shorting a grid does not cause the next tube to respond to ground, increase the grid resistor (R17, R20, or R27) of that next tube slightly and repeat sequence test. Measure

vertical sync. pulse from TV set and adjust 15-150 padder capacitor to lowest capacity which will give reliable trimmer operation.

Final adjustment of the reference tuning is accomplished while receiving a color telecast. While making the following adjustments keep the TV set fine tuning detuned sufficiently so that the test point voltage is less than 2 volts (This prevents limiting action of diodes D1 and D2). Adjust C43, C23 and C18 to peak the test point voltage. C43 is set at minimum. To obtain best performance from the burst gate, adjust the value of R29 (which controls the horizontal pulse amplitude in the Colorsyncator) to obtain maximum test point voltage.

Also, adjust the horizontal hold control to obtain maximum test point voltage. When the TV fine tuning is then adjusted for proper color operation, the test point voltage will rise to a limiting value of about 3 volts and then be relatively independent of the fine tuning adjustment.

The color wheel may now be started and adjusted for synchronism. Turn the R28 slider to B+ side and adjust R21 so color wheel goes slightly too slow, that is when bars appear to go in the opposite direction as the color wheel rotation. When the color wheel speed is correct, a white picture is seen with a clear grey bar occasionally crossing the picture. Now turn R28 slider to the ground end. The grey bar should now go through the picture in the same direction to the color wheel rotation. The color wheel can now be synchronized by adjusting R-28.

To obtain proper phasing of the color wheel, the synchronizer pole pieces should be moved relative to the color wheel, so that as the blue filter starts across the TV screen the pole pieces are just passing the pickup coil.

If proper color wheel speed cannot be obtained as above, check pulley ratios, and if the wheel is too fast, additional series resistance can be added to the motor circuit.

With the color wheel properly synchronized, a full color picture should now be obtainable. The color gain is controlled by R2 and will also be strongly affected by the TV set fine tuning. In an intercarrier set adjust the fine tuning until the sound interference just disappears from the picture. C42 the neutralizing capacitor is adjusted to remove the rainbow like color distortion at the left hand side of the picture.

The final adjustment is the color phase. With the color wheel properly synchronized and a color signal present, the reference phase, C23 can be adjusted to obtain pleasing flesh tones and red lipstick. Capacitor C23 gives the greatest color phase range, but C43 also affects color. If proper color phase is unobtainable reverse the leads to either L3 or L4 but not both, and again adjust phase controls. Do not adjust C18 to change color phase.

SERVICE NOTES

Troubles are listed and possible remedies noted. It is suggested that a non-functioning unit be checked in the order given. The Resistance and Voltage Measurements Chart will be useful in checking an inoperative unit.

No Black and White Picture

1. Turn COLORDAPTOR off. If still no B. and W. picture, check delay line installation.
2. If COLORDAPTOR "on" cuts off B. and W. picture, check C11 for leakage.
3. Remove COLORDAPTOR entirely and check TV set.

No Color Wheel Sync.

1. Tritch not operating.
2. No vertical sync pulse or V7B defective.
3. Insufficient voltage from sync pickup coil. Decrease spacing between pickup coil and pole pieces.
4. Check phase detector V7 operation by measuring plate voltage of V7B. As color wheel slips sync this voltage should vary from about 200 to 70 volts. If not, see 2 and check V7 and associated circuits.
5. With R48 turned to ground and adjust R61 so color wheel runs slightly fast. Then adjust R48 to obtain color wheel sync. If color wheel speed does not change check V8.

No Color

1. No color program transmission or improperly connected color bar generator.
2. Reference test point voltage less than 2 volts.
   a. Insufficient horizontal sync pulse. Adjust R62.
   b. Incorrect horizontal locking phase. Adjust horizontal lock control on TV set.
   c. Preamplifier V9 incorrectly attached. Check voltages and check twisted pair to insure that same wire is grounded at both ends.
   d. Adjust fine tuning control for max. test point voltage consistent with good B. and W. picture.
   e. Check limiter diodes in V9B output circuit for polarity (arrow). Back resistance should be greater than 20,000 ohms.
   f. Check tubes V3 and V6.
   g. Adjust color reference tuning C41, C23 and C19 for max. test point voltage.
3. Quick rotation of color gain R9 should produce temporary fluctuation of brightness. If no fluctuation, check video output amplifier tube, V11. Also check connection from COLORDAPTOR to TV set pix tube, Figure 2.
4. Short pin 1 to pin 3 of V2. Picture brightness should fluctuate. If not, check V2 and item 3 above.
5. Check chroma amplifier response V1 as outlined in COLORDAPTOR specifications.
6. Reference phase switch V4A, V4B, and V5A (Tritch) not sequencing. Plate to Gr voltage should be about 20 volts on all three tubes.
   a. Check V4 and V5 and diode polarities. Back resistance should be greater than 500 K ohms. (arrow)
   b. Insufficient vertical sync voltage. Adjust R63.
   c. If vertical sync OK and one plate voltage is at about 60 volts measured from Gr, short grid resistor (500K) of that tube with 10 meg resistor until other tubes start switching.

COLORDAPTOR

[illegible] last a reliable and proven color converter for your black and white TV set - [illegible]ses, COLORDAPTOR is your ticket for admission to the ever expanding number of COLOR SPECTACULARS. Join the thousands who have already converted their black and white sets to color and are now enjoying the marvels of modern color television.

Expensive? Not with COLORDAPTOR. This proven color conversion can be made at a price even the budget minded experimenter can afford. The basic parts kit costs less than $20 and all the remaining parts can be obtained from the scrap box or from your TV parts supplier.

COLORDAPTOR consists of a ten tube electronic chassis which in conjunction with a rotating color wheel will convert any size black and white TV, direct view or projection, to receive compatible color TV. Attachment of the COLORDAPTOR to the standard TV set is simple and in no way affects its normal operation.

COLORDAPTOR was first described in the January and February 1956 issues of Radio-Electronics. We now offer the new COLORDAPTOR Model C415A embodying the improvements of four years of field testing. This is a simple and soundly engineered converter which has been designed for optimum performance and a minimum of trouble. The following construction plans and parts kits for the Model C415A are available to aid and simplify the construction of your COLORDAPTOR.

PRICE LIST*

CD-S1	Complete specifications of NEW Model C415A COLORDAPTOR including theory of operation, simplified construction plans, schematic diagram, resistance and voltage measurements, operating and service hints, sample color filters	$ 1.95
	(S-1 with any order for a "K" or "M" kit)	.50
CD-S5	Full 11" x 17" COLORDAPTOR schematic	.75
CD-K11	Essential parts kit - contains all coils, rf transformer, 3.579545 mc crystal, delay line, and tricolor filter material. (includes K-5, 6, 7, 8, 9, 10).	
	K11A for sets up to 16"	19.95
	K11B sets 17" or larger	20.95
	K11C Heavy duty filters up to 16".	25.95
	K11D Heavy duty filters up to 21".	32.95
CD-K1	Complete COLORDAPTOR electronic chassis includes pre-punched chassis, all components including tubes, preamplifier, delay line, assembly instructions. This kit and your color wheel give brilliant color on any black and white TV. Color wheel and drive not included in kit. Ready to assemble and wire. Model C415A	89.95
CD-KW1	Above electronic chassis completely wired and tested on a Compatible Color TV transmission before shipment. Complete instructions for attachment to standard black and white TV. Ready to operate	179.95

*Prices subject to change.

March, 1961

No Black and White Picture

1. Turn COLORDAPTOR off, if still no B. and W. picture, check delay line installation.
2. If COLORDAPTOR "on" cuts off B. and W. picture, check C11 for leakage.
3. Remove COLORDAPTOR entirely and check TV set.

No Color Wheel Sync.

1. Tritch not operating.
2. No vertical sync pulse or V5B defective.
3. Insufficient voltage from sync pickup coil. Decrease spacing between pickup coil and pole pieces.
4. Check phase detector V7 operation by measuring plate voltage of V7B. As color wheel slips sync this voltage should vary from about 200 to 30 volts. If not, see 2 and check V7 and associated circuits.
5. With R15 turned to ground and adjust R61 so color wheel runs slightly fast. Then adjust R58 to obtain color wheel sync. If color wheel speed does not change check V8.

No Color

1. No color program transmission or improperly connected color bar generator.
2. Reference test point voltage less than 2 volts.
   a. Insufficient horizontal sync pulse. Adjust R49.
   b. Incorrect horizontal locking phase. Adjust horizontal lock control on TV set.
   c. Preamplifier V3 incorrectly attached. Check voltages and check twisted pair to insure that some wire is grounded at both ends.
   d. Adjust fine tuning control for max. test point voltage consistent with good B. and W. picture.
   e. Check limiter diodes in V4B output circuit for polarity [diode symbol]. Back resistance should be greater than 20,000 ohms.
   f. Check tubes V3 and V4.
   g. Adjust color reference tuning C43, C57 and C18 for max. test point voltage.
3. Quick rotation of color gain R9 should produce temporary fluctuation of brightness. If no fluctuation, check video output amplifier tube, V11. Also check connection from COLORDAPTOR to TV set pix tube, Figure 8.
4. Short pin 1 to pin 3 of V9. Picture brightness should fluctuate. If not, check V9 and item 3 above.
5. Check chroma amplifier response V1 as outlined in COLORDAPTOR specifications.
6. Reference phase switch V6A, V6B, and V5A (Tritch) not operating. Plate to B+ voltage should be about 30 volts on all three tubes.
   a. Check V4 and V5 and diode polarities. Back resistance should be greater than 500 K ohms. [diode symbol]
   b. Insufficient vertical sync voltage. Adjust R52.
   c. If vertical sync OK and one plate voltage is at about 60 volts measured from B+, shunt grid resistor (560K) of that tube with 10 meg resistor until other tubes start switching.

-8-

COLORDAPTOR

At last a reliable and proven color converter for your black and white TV set - yes, COLORDAPTOR is your ticket for admission to the ever expanding number of COLOR SPECTACULARS. Join the thousands who have already converted their black and white sets to color and are now enjoying the marvels of modern color television.

Expensive? Not with COLORDAPTOR. This proven color conversion can be made at a price even the budget minded experimenter can afford. The basic parts kit costs less than $20 and all the remaining parts can be obtained from the scrap box or from your TV parts supplier.

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*Prices subject to change.

March, 1961

SPECIAL COLORDAPTOR PARTS

CD-K5	Delay line - easily adjustable to give correct delay for any set	$5.75
CD-K6	Ref. Phase Shift Coils $L_{10,11,12,13}$	3.65
CD-K7	Double tuned xfmr. L_3 - L_4	2.
CD-K8	Miscellaneous Coil Kit $L_{1,2,5,7,8,9,14,15,16}$	3.95
CD-K9	3.579545 mc Crystal	3.25
CD-K10A	Color Filter Material - sets to 16"	2.35
CD-K10B	Above Filters - sets 17" and larger	4.15
CD-K12A	Special heavy duty celluloid color wheel filters, .010" thick Red, green, and blue sheet - up to 16" wheel	7.95
CD-K12B	Same as above except two sheets each - up to 21"	15.95
CD-K13	Above filters for self-supporting projection color wheel	4.95
CD-T3	Signal generator plug-in crystal 3.579545 mc	3.95
CD-T4	Signal generator plug-in crystal 3.563795 mc	3.95

Here's a LOW COST COLOR TV CONVERTER

That

REALLY PERFORMS

COLORDAPTOR

1798 Santa Cruz Avenue ••••• Menlo Park, California

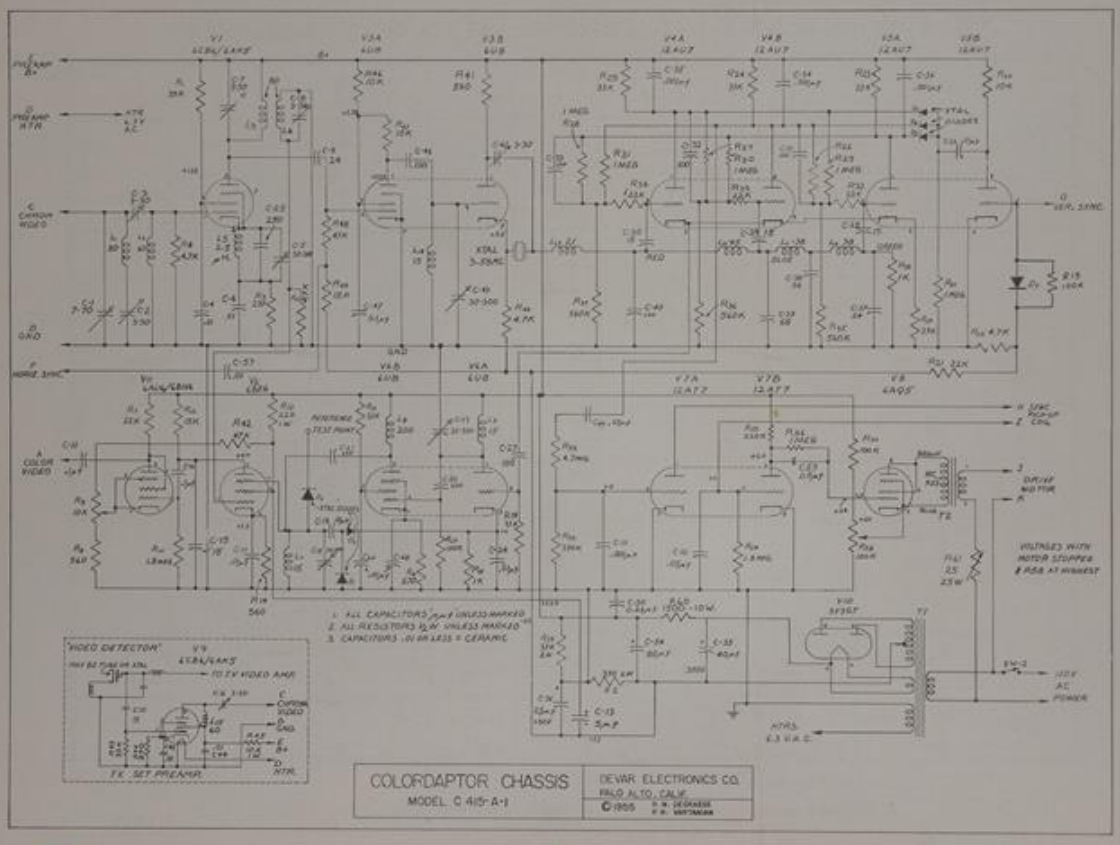
MOTORS - Following motors are all compact lightweight induction motors specially suited to drive a color wheel. All operate from 115V 60 cps line at a speed of approximately 1500 RPM.

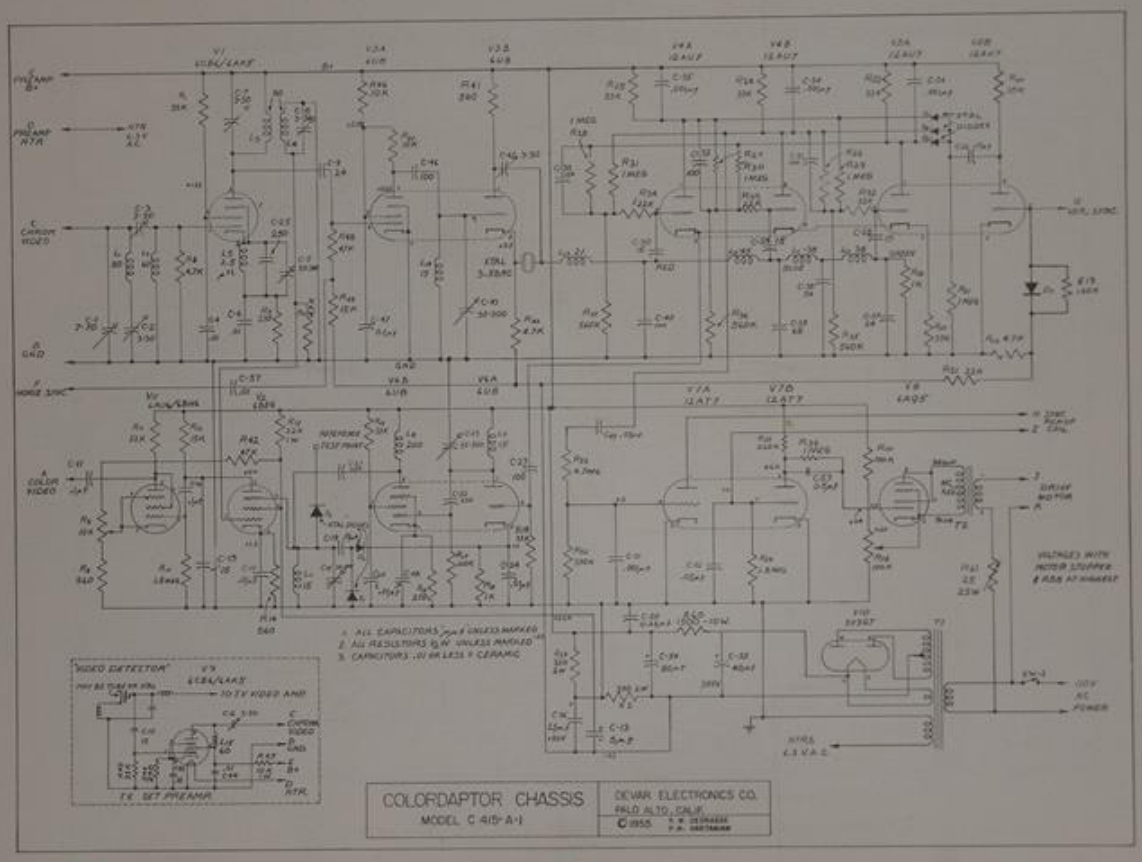
CD-M1	1/70 HP motor may be used to direct drive a 1200 RPM projection wheel or pulley drive up to 7" TV set color wheel. 1/4" dia. shaft 2 bolt mounting	$11.95
CD-M2	1/30 HP motor to pulley drive up to 16" TV set color wheel. 5/16" dia. shaft 4 bolt mounting	14.95
CD-M3	1/15 HP motor to pulley drive up to 21" TV set color wheel. 3/8" dia. shaft 4 bolt mounting	17.95

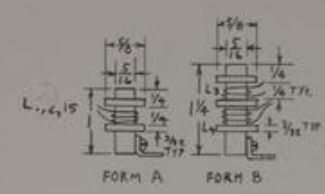
SHIPPING - Kits postpaid except: K-1 - 12 lb; KW-1 - 12 lb; (Rail Express) M-1 - 3 lb; M-2 - 4 lb; M-3 - 6 lb.

TERMS Net cash. - International shipments add 10%. California residents add 3% Sales Tax.

COLORDAPTOR 1798 Santa Cruz Ave. Menlo Park, Calif.


COLORDAPTOR CHASSIS
MODEL C 415-A-1
DEVAR ELECTRONICS CO.
PALO ALTO, CALIF.
©1965
1. ALL CAPACITORS µµf UNLESS MARKED
2. ALL RESISTORS ½W UNLESS MARKED
3. CAPACITORS .01 OR LESS = CERAMIC
"VIDEO DETECTOR"
TO TV VIDEO AMP
TK SET PREAMP
VOLTAGES WITH MOTOR STOPPED & POT AT HIGHEST
DRIVE MOTOR
110V AC POWER
HTRS. 6.3 V.A.C.


COLORDAPTOR CHASSIS
MODEL C 415-A-1
DEVAR ELECTRONICS CO.
PALO ALTO, CALIF.
©1955
"VIDEO DETECTOR"
10-7V VIDEO AMP
1X SET PREAMP
VOLTAGES WITH MOTOR STOPPED & FOCUS AT MINIMUM
1. ALL CAPACITORS ≥ 1 μf UNLESS MARKED
2. ALL RESISTORS ½W UNLESS MARKED
3. CAPACITORS .01 OR LESS = CERAMIC
110V AC POWER



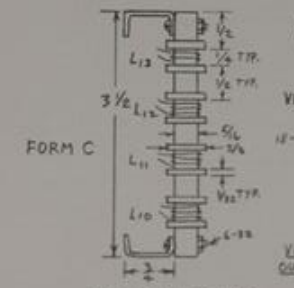


FIG. 7. COIL FORMS

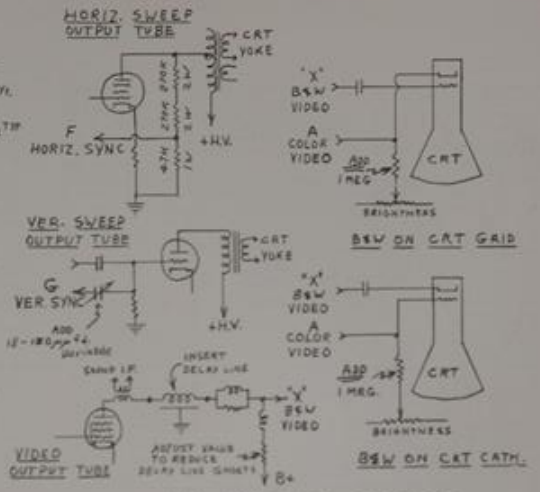


FIG. 8 CONNECTIONS TO TV SET

FIG. 9 DELAY LINE

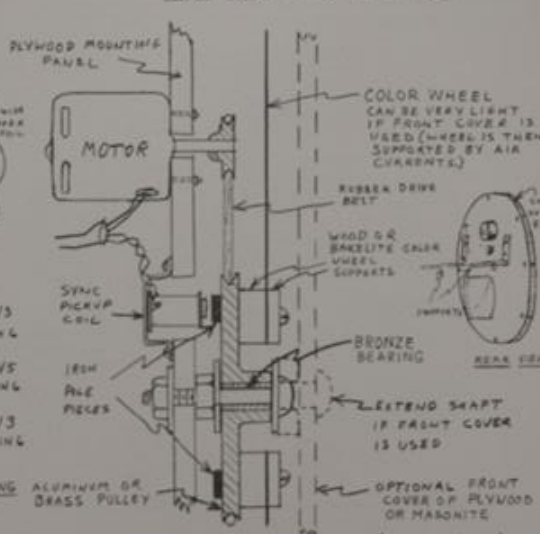


FIG 12 COLOR WHEEL DRIVE

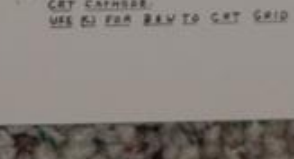


FIG. 10. RETRACE BLANKING

USE (a) AND (b) FOR B&W TO CRT CATHODE.
USE (c) FOR B&W TO CRT GRID

Giselle MacKenzie . . . Star of "Your Hit Parade"

COL-R-TEL

Color converter

YOUR ANSWER TO COLOR TV

Superb Color

AND THE FINEST BLACK AND WHITE

are yours when you own a low cost . . .

COL-R-TEL *Color converter*

COL-R-TEL gives you magnificent color yet costs but a fraction of a separate color receiving set. With COL-R-TEL you save TWO ways because you need only one receiver . . . your present black and white set. There is no need to wait for color. It's here . . . and you owe it to yourself to have it now.

Because the COL-R-TEL converter in no way affects black and white reception, you receive black and white as perfectly as your present set is capable of receiving it. You sacrifice neither size of picture or quality, nor does COL-R-TEL impair the life of tubes or circuits of your receiver.

COL-R-TEL is sold, installed and serviced by reliable dealers

Mfg. by COLOR CONVERTER, INC., Columbia City, Indiana

BULK RATE

for:

YOUR ANSWER TO

Color-TV

Superb Color

AND THE FINEST BLACK AND WHITE

are yours when you own a low cost . . .

COL-R-TEL *Color converter*

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BULK RATE

YOUR ANSWER TO

Color-TV

Gisele MacKenzie . . . Star of "Your Hit Parade"

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BULK RATE

YOUR ANSWER TO

Color-TV

for:

Gisele MacKenzie . . . Star of "Your Hit Parade"

COL-R-TEL *Color converter*

YOUR ANSWER TO COLOR TV

NOW! MAGNIFICENT NATURAL COLOR TV

at a price you can easily afford!

COL-R-TEL PERMITS EITHER COLOR OR BLACK & WHITE RECEPTION.

COL-R-TEL RESTS ON TV CABINET ON SOFT RUBBER. NO MARKING.

COL-R-TEL EASILY LIFTS ON OR OFF TV CABINET. ONE PLUG CONNECTION.

COL-R-TEL IN NO WAY AFFECTS LIFE OR PERFORMANCE OF THE TV SET OR TUBES.

COL-R-TEL ELECTRONIC UNIT ADAPTS PICTURE SIZE TO FIT COLOR PICTURE AREA.

COMPLETE PICTURE IS RESIZED AND CONVERTED TO COLOR WHEN COLOR IS BROADCAST.

COL-R-TEL *Color converter*

Thrill to the exciting beauty of full-color reception with your present black and white television set! When color is broadcast you will receive programs in all the glorious hues and tones that the finest color-casting can produce.

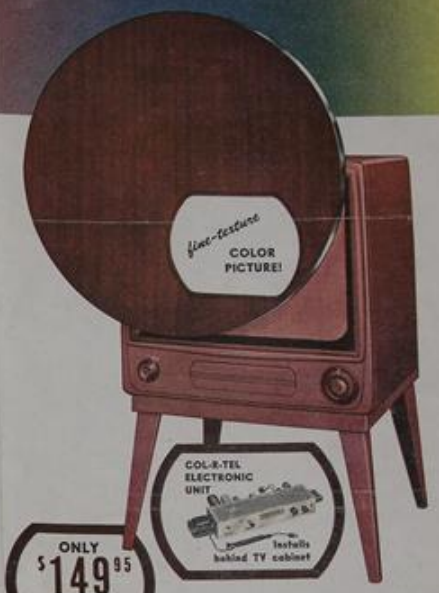
The quality of color reception is excellent and the COL-R-TEL color converter is unbelievably low in price. If your TV receiver now produces a good black and white picture, and your local TV stations transmit good color quality . . . you are ready for COL-R-TEL.

FOR ALL SIZES OF BLACK AND WHITE CONSOLE OR TABLE MODEL TV SETS

COL-R-TEL converts any black and white set for color. The complete picture is electronically sized to the picture area for fine-texture color viewing. When programs are viewed in black and white, the set is used with normal screen size in the conventional manner. You turn a switch to reduce the picture to converter size or to restore the original size for black and white.

EASILY INSTALLED . . . NO SERVICE PROBLEMS

The COL-R-TEL electronic unit may be installed behind the cabinet by your dealer. The color-viewing screen is a portable, plug-in, lightweight unit that rests on rubber cushions on top of the cabinet when color programs are viewed. The electronics and mechanics of COL-R-TEL are simplified to permit easy, low-cost servicing or replacement of parts by any television serviceman.



ONLY $149.95 READY TO INSTALL

Installation cost varies with TV sets and local conditions. Ask your COL-R-TEL dealer.

Complete . . . NO EXTRAS TO BUY . . . .

The cost of COL-R-TEL is so low you would expect hidden "extras." There are none. If you can afford black and white TV . . . you can now afford COLOR with COL-R-TEL, your answer to color TV.

VIEWING UNIT MAY BE STORED WHEN SET IS USED FOR BLACK AND WHITE TELECASTS.

ONLY THREE CONTROLS. OPERATION IS AS SIMPLE AS TUNING A BLACK & WHITE TV SET.

QUALITY OF COLOR PICTURE IS EQUAL TO QUALITY OF AREA RECEPTION AND CONDITION OF TV SET.

SERVICE UPKEEP IS NEGLIGIBLE BECAUSE COL-R-TEL PARTS ARE INEXPENSIVE.

ANY COMPETENT TV SERVICEMAN CAN SERVICE A COL-R-TEL UNIT.

COL-R-TEL IS THE LOWEST COST, FINE QUALITY COLOR INSTRUMENT AVAILABLE.

CONVERT YOUR PRESENT TV SET TO RECEIVE COLOR TELECASTS NOW!

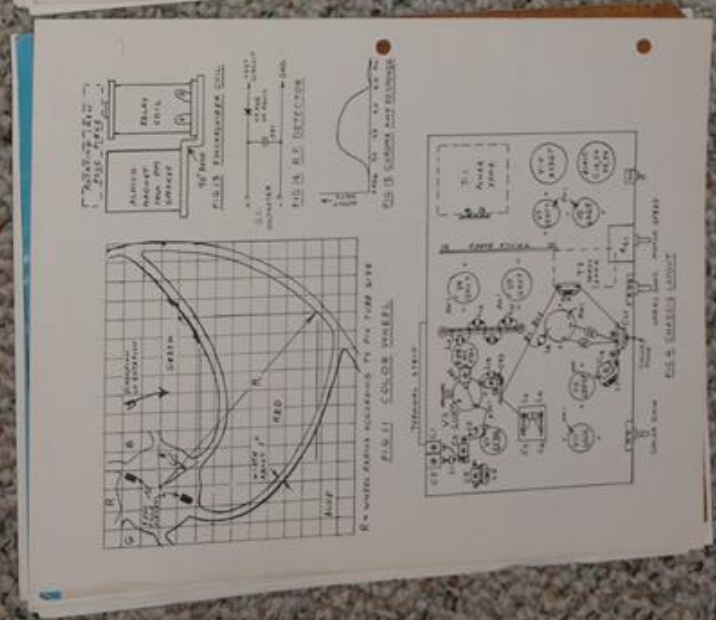

Recent
Acquisitions

COLORDAPTOR MODEL C-415A RESISTANCE AND VOLTAGE# MEASUREMENTS

	1	2	3	4	5	6	7	8	9	Remarks
V_1	2 +0	270 +2.7	0 0	0 ±6.3	2* +220	39K* +125	270 +2.7			
V_2	2 +0	560 +2.5	0 0	0 ±6.3	150K* +205	220K* +92	2 +0			No Horiz. Sync
V_3	560* +217	42K −26	100K* +220	0 0	0 ±6.3	20K* +220	0 +0	98K +4.7	2 +0	V5A Conductg.
V_4	33K* +205	300K +83	39K +107	0 0	0 0	33K* +205	300K +83	39K +107	0 ±6.3	V4A Conductg.
V_5	33K* +205	300K +83	39K +107	0 0	0 0	100K* +165	3K+ 1 Meg −3.5	0 +0	0 ±6.3	Meter Polarity Pin 7
V_6	2* +220	100K +0	33K* +155	0 0	0 ±6.3	7.5* +220	270 +3.3	1K+ 220− +6.0	33K +0	Meter Polarity Pin 8
V_7	1.8 Meg +0	390K +0	0 +8	0 0	0 0	220K* +42	1.8 Meg +0	0 +0	0 ±6.3	R38 at D#end
V_8	420K +15	50K +100	0 0	0 ±6.3	50K +100	50K +100	420K +15			
V_9	33K +0	120 +2.3	0 0	0 ±6.3	100K* +1	100K* +135	120 +2.3			
V_{10}	NC	~750 +110	NC	420 ±290	NC	420 ±290	NC	~750 +310		R9 at D#end
V_{11}	1.8 Meg +0	9K +43	0 0	0 ±6.3	220K* +220	220K* +220	9K +43			

* Resistance measured to 220 bus

\# Voltage measurements made with 20,000 Ω/v. multimeter, with color wheel inoperative and with no synchronizing pulses.




RCA CTC-7


The Incomparable
Muntz TV
television triumph !


The Incor
Mu
erica's Televi

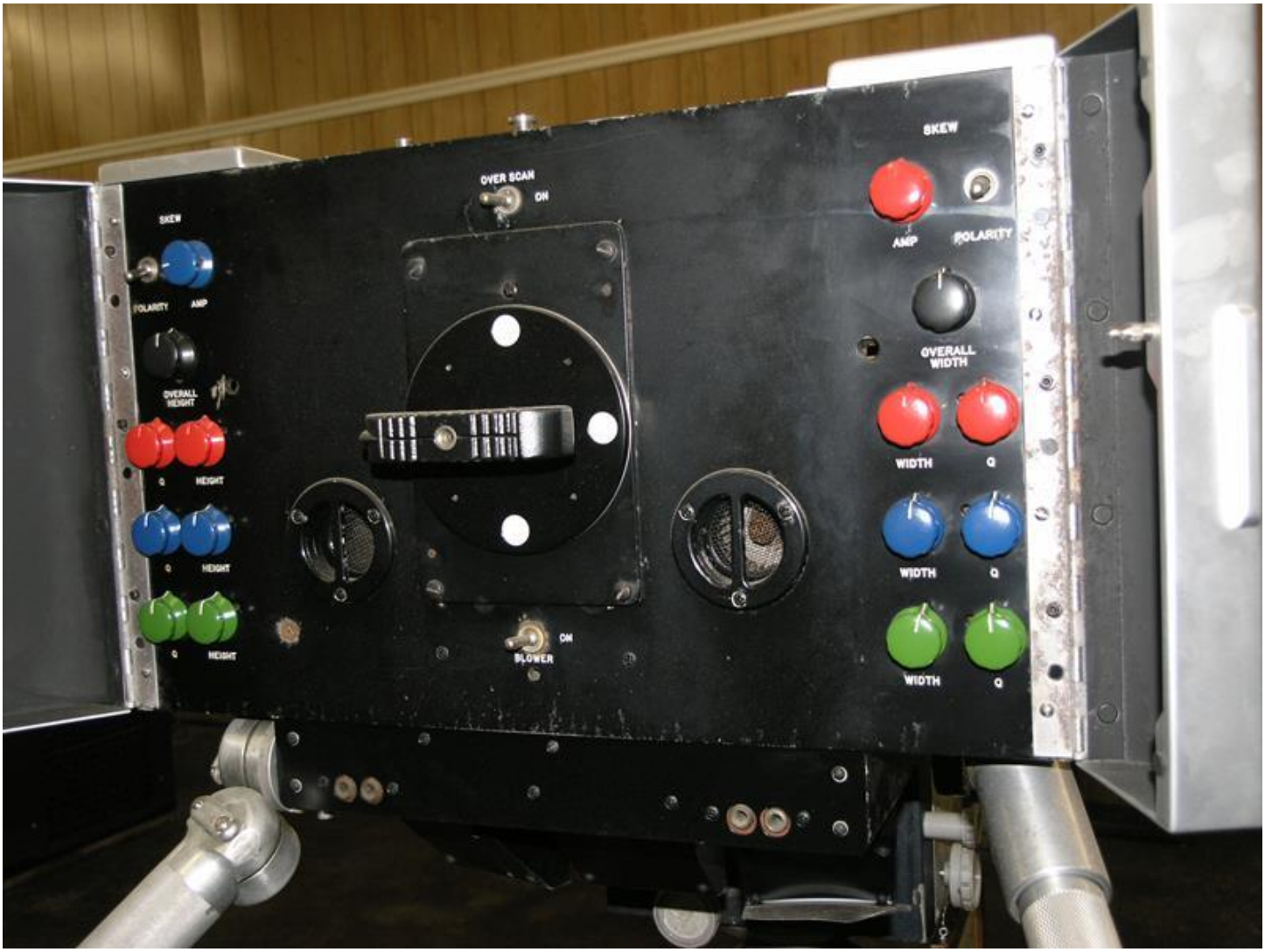

30BP4
This tube was made by DuMont in 1951 for the Royal Sovereign. It is the largest black and white tube ever made.
5GP22
1936 German CRT


DANGER
15,000 VOLTS
WITH CAUTION
RUBBER GLOVES
WHEN SERVICING


X9
Hi-Brite


W·G·S·F TV. 31
Color Television


WGSF 31
TELEVISION
TV. 31
TV-13
RCA
Color Television
RCA TK-41 Color Camera


SKEW
POLARITY
AMP
OVERALL HEIGHT
Q
HEIGHT
Q
HEIGHT
Q
HEIGHT
OVER SCAN
ON
ON
BLOWER
SKEW
AMP
POLARITY
OVERALL WIDTH
WIDTH
Q
WIDTH
Q
WIDTH
Q


The Incomparable
Muntz
Muntz TV
America's Television Triumph !


Simpson 406
Chromatic
Amplifier
Used to amplify video and chroma signals for low sensitivity oscilloscopes.
(Donated by Bill Walter, restored by Joe Sousa)
Simpson
CHROMATIC AMPLIFIER
OFF
ON


W·G·S·F TV. 31


TV 13
Television


Color Television


RCA
Color Television


RCA
Color TV
XL-100


RCA


TT5


RCA
Color TV
XL-100
100% Solid State


INCOMING
UPS
Miracle-Gro
Cactus
Palm & Citrus Soil


WARNING
BROADCAST STATION

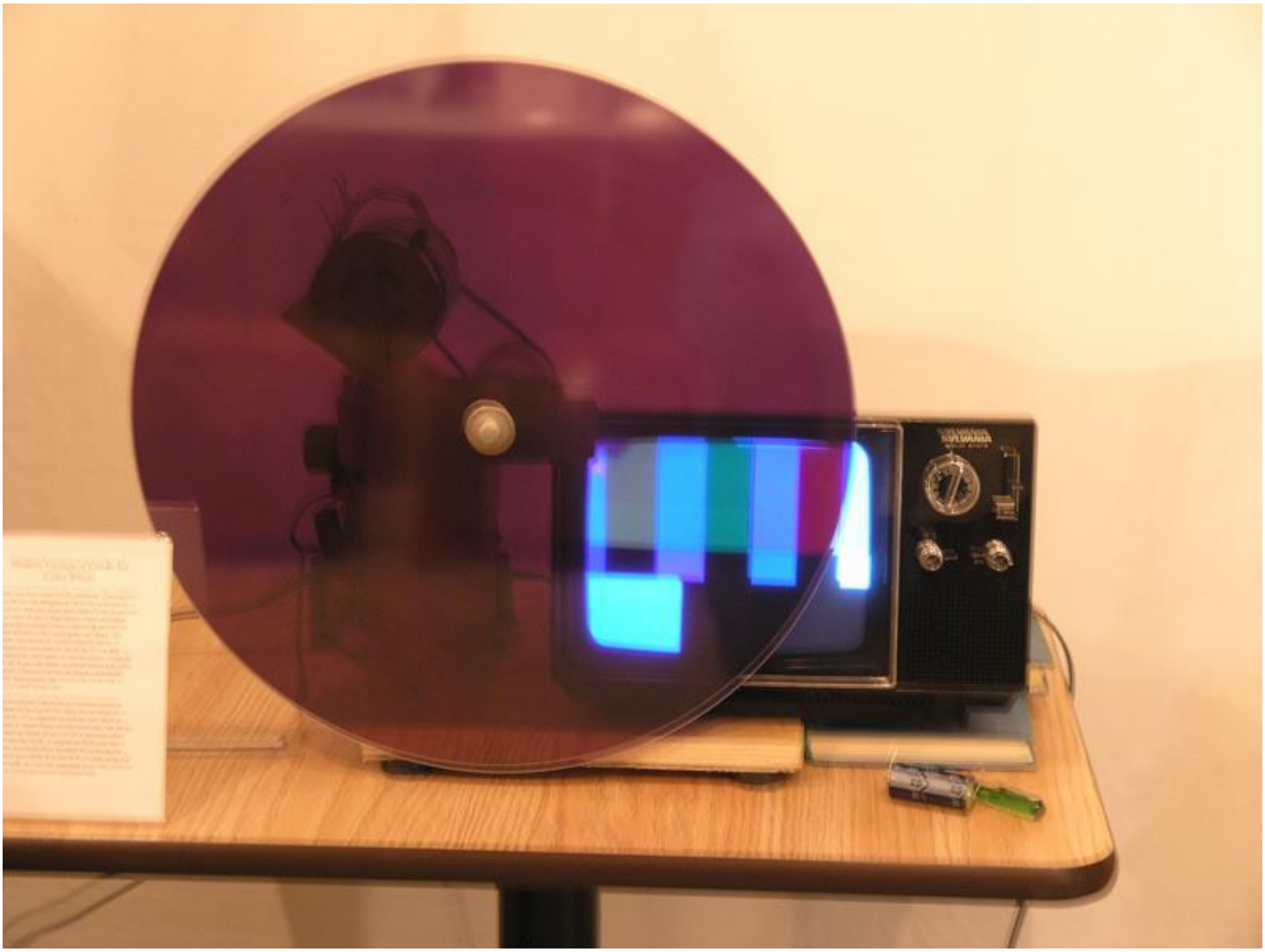

33


WARNING
SECURE ALL LOADS
BRCH700
BRCH700


VERTICAL DYNAMIC
TILT
BOW
RED-GREEN
SIZE
LINEARITY
BLUE
SIZE
LINEARITY
STATIC
R-G HOR POS
R-G VERT POS
BLU HOR POS
BLU VERT POS
HORIZONTAL DYNAMIC
RIGHT SIDE
R-G TILT
R-G SIZE
LEFT SIDE
R-G TILT
R-G SIZE
BLUE
LEFT SIDE TILT
RIGHT SIDE TILT
BRIGHTNESS
CONTRAST
GAIN
EXT
INT
BOW
SCRN
MONO
CHROMA
BAL
SNITY
RED
YAW
RED SCRN
GRN SCRN
BLW SCRN
AC RESET
ON
OFF
UNDER
NORM
VERT
VERT LIN A


RCA TM-21 Color Monitor
This is RCA's first 21 inch color studio monitor. It was introduced in 1955, and was in use for over a decade. It was donated to the museum by Noland Stefany.


SONY
RVP-6010Q
POWER
STANDBY
LIGHT
SONY
MEMORY
STATUS ON
OFF
SECAM
C.B.
RGB SIZE
SHIFT
CENT R
B
INPUT SELECT
VIDEO
A
B
PAGE
RESET
PJ MUTING
PIC
AUDIO
POWER
OFF
ON
SWITCHER
1
2
3
4
5
6
7
8
SECOND
PICTURE CONTROL
HUE
SHARP
BRT
COLOR
CONTR
VOL
CUT OFF
R
G
B
ADJ
R
G
B
BLKG
W/B
BIAS
GAIN
REGISTRATION
TEST
NORMAL
SIZE
LIN
SKEW
BOW
KEY
PIN
ZONE
POSITION


SYLVANIA
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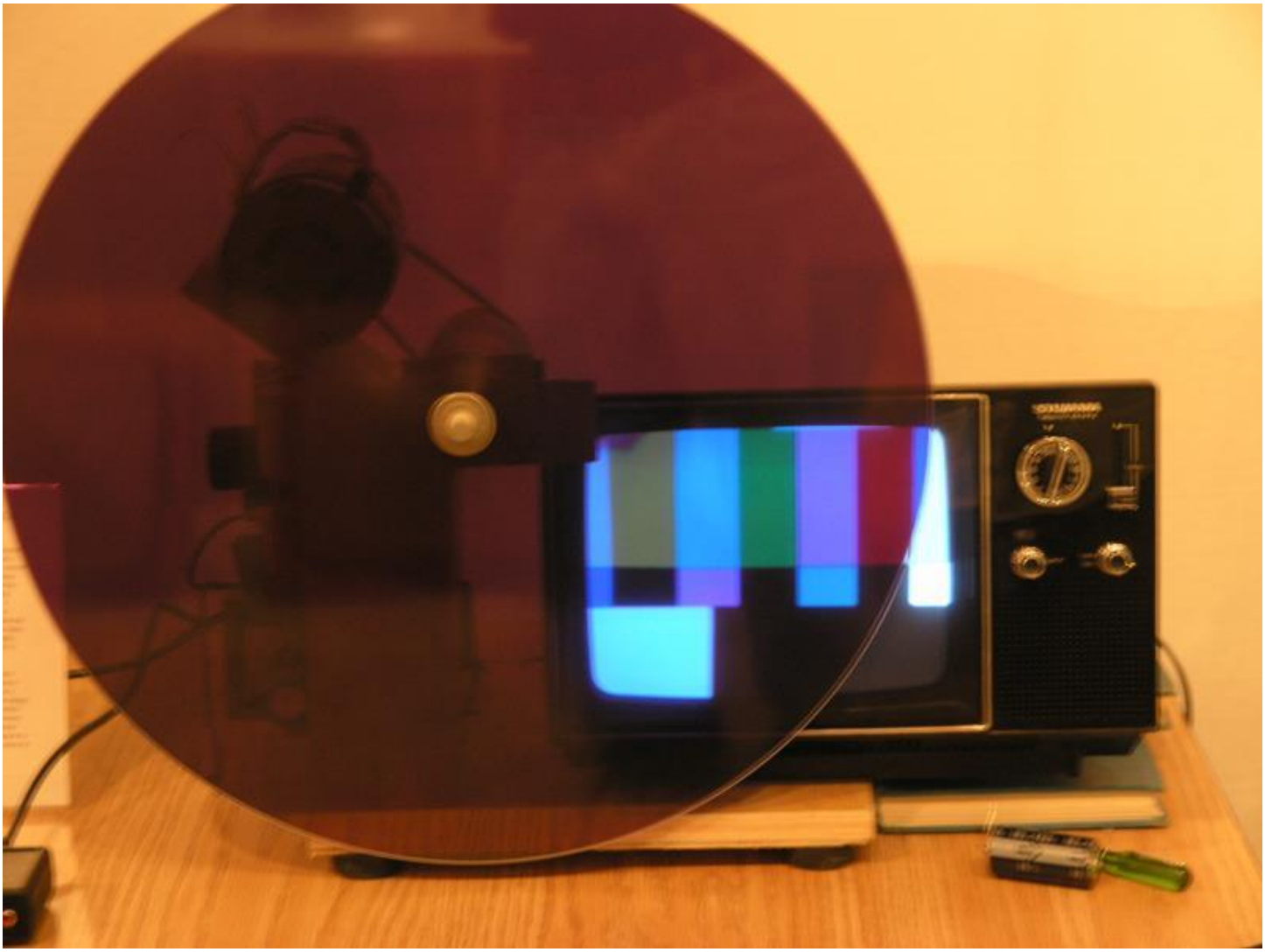

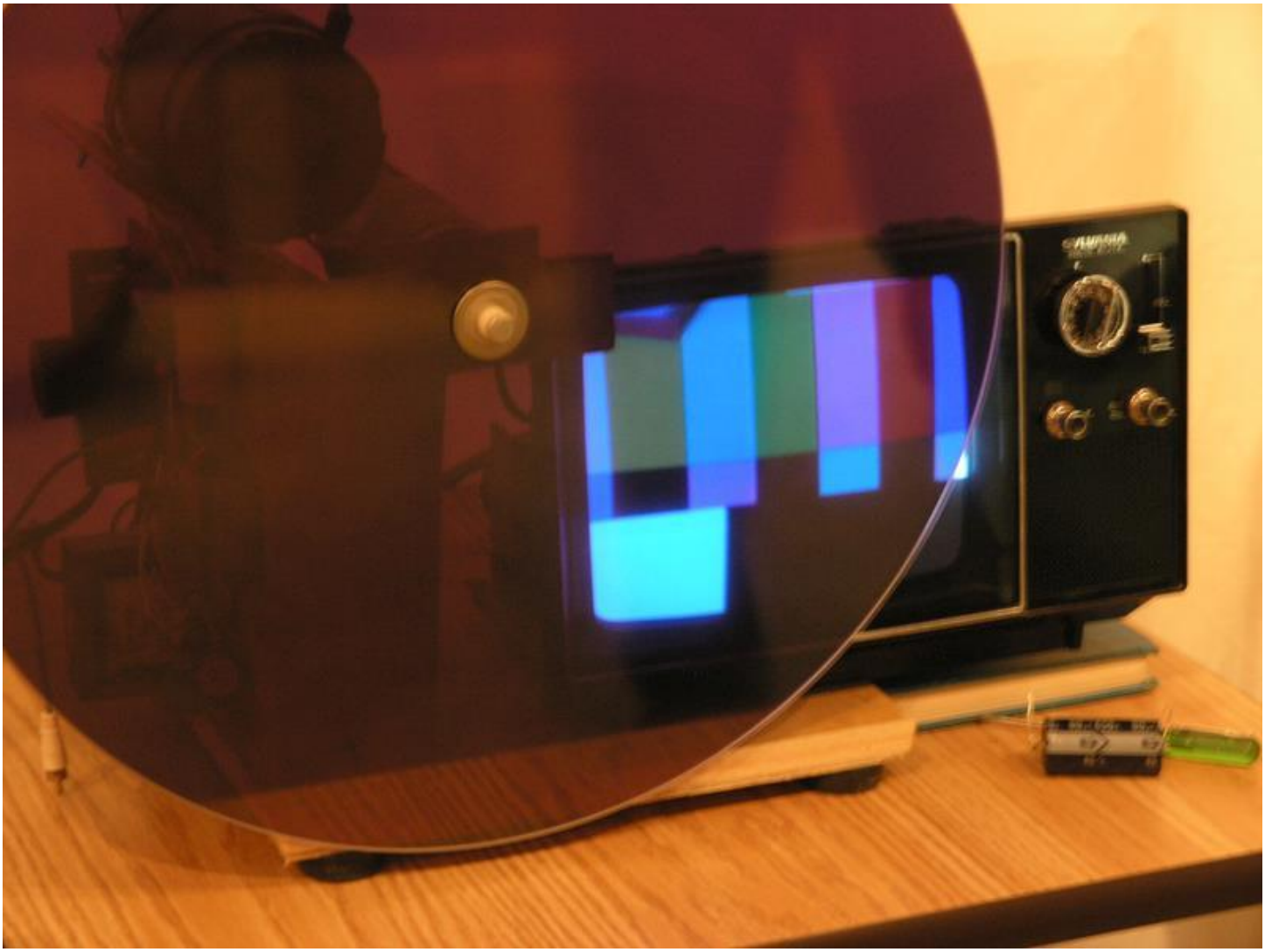
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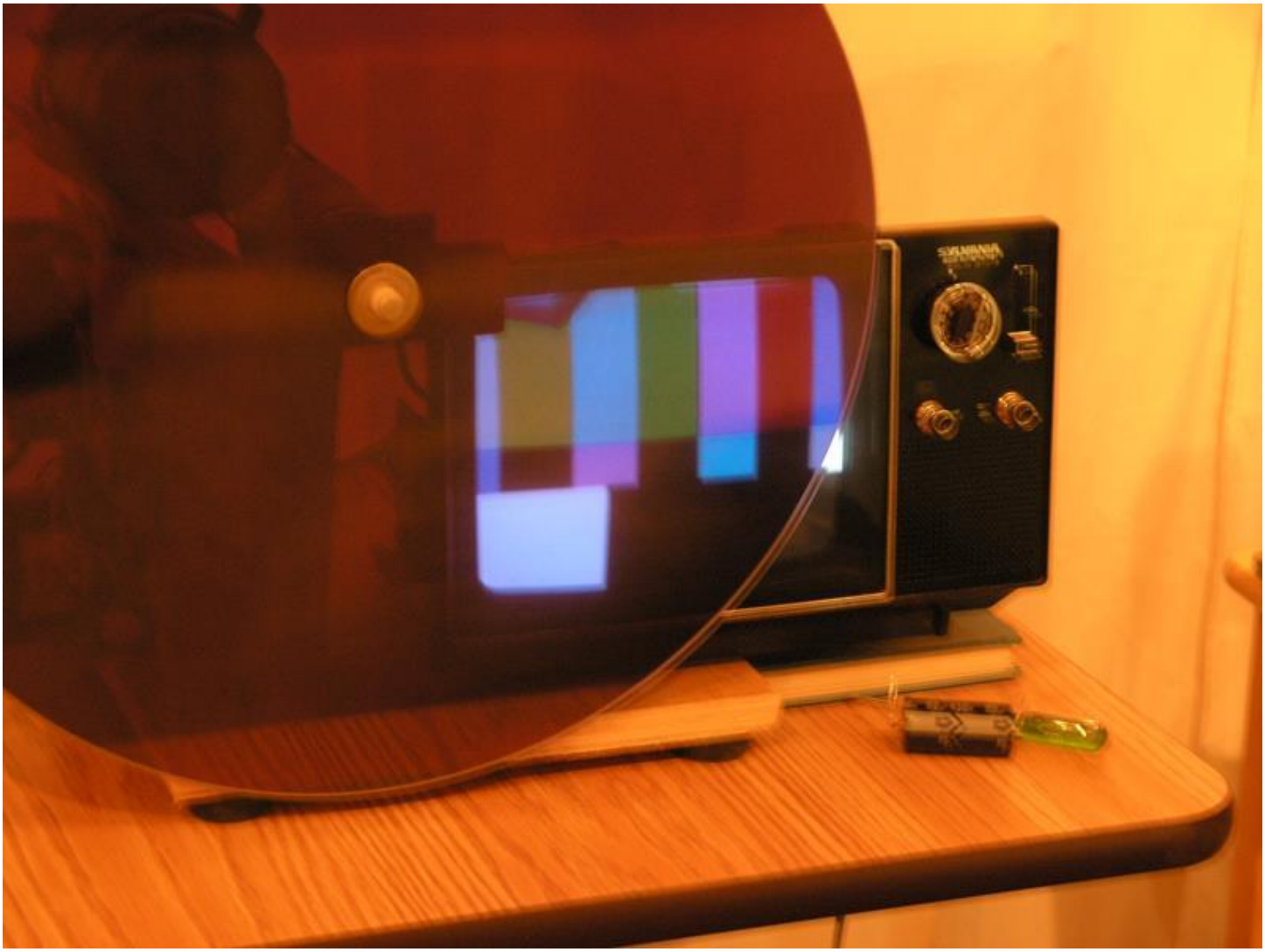
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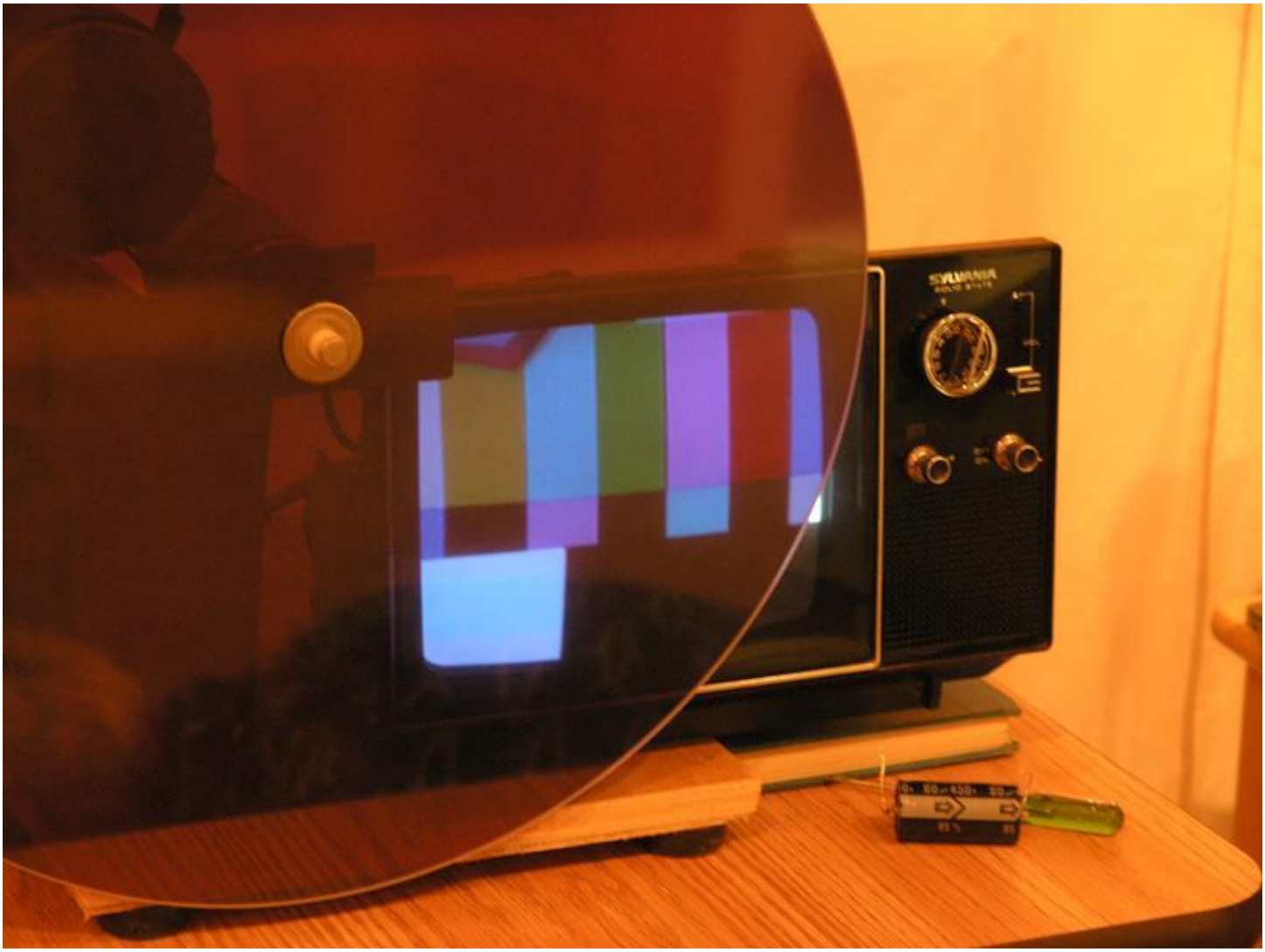
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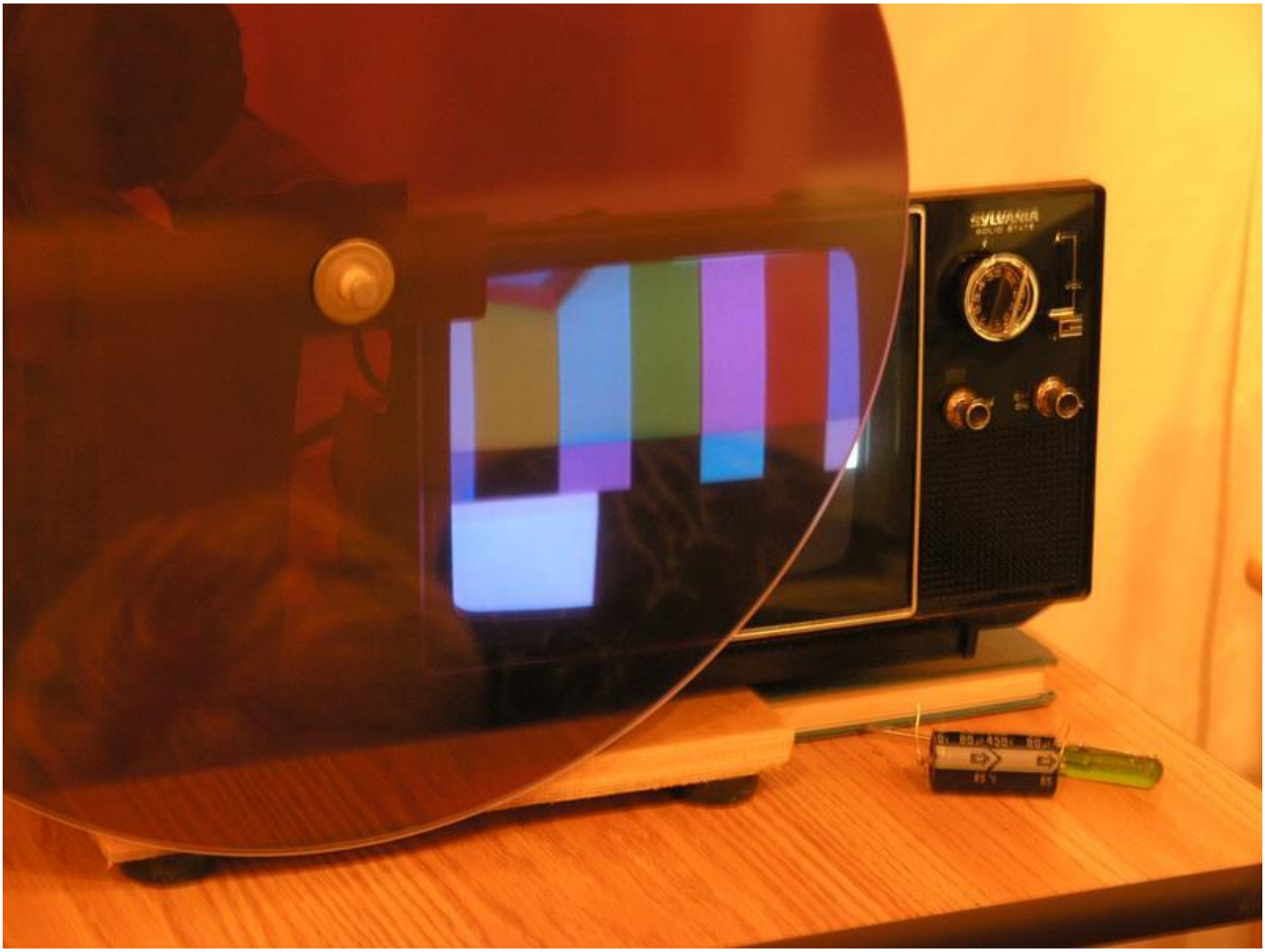
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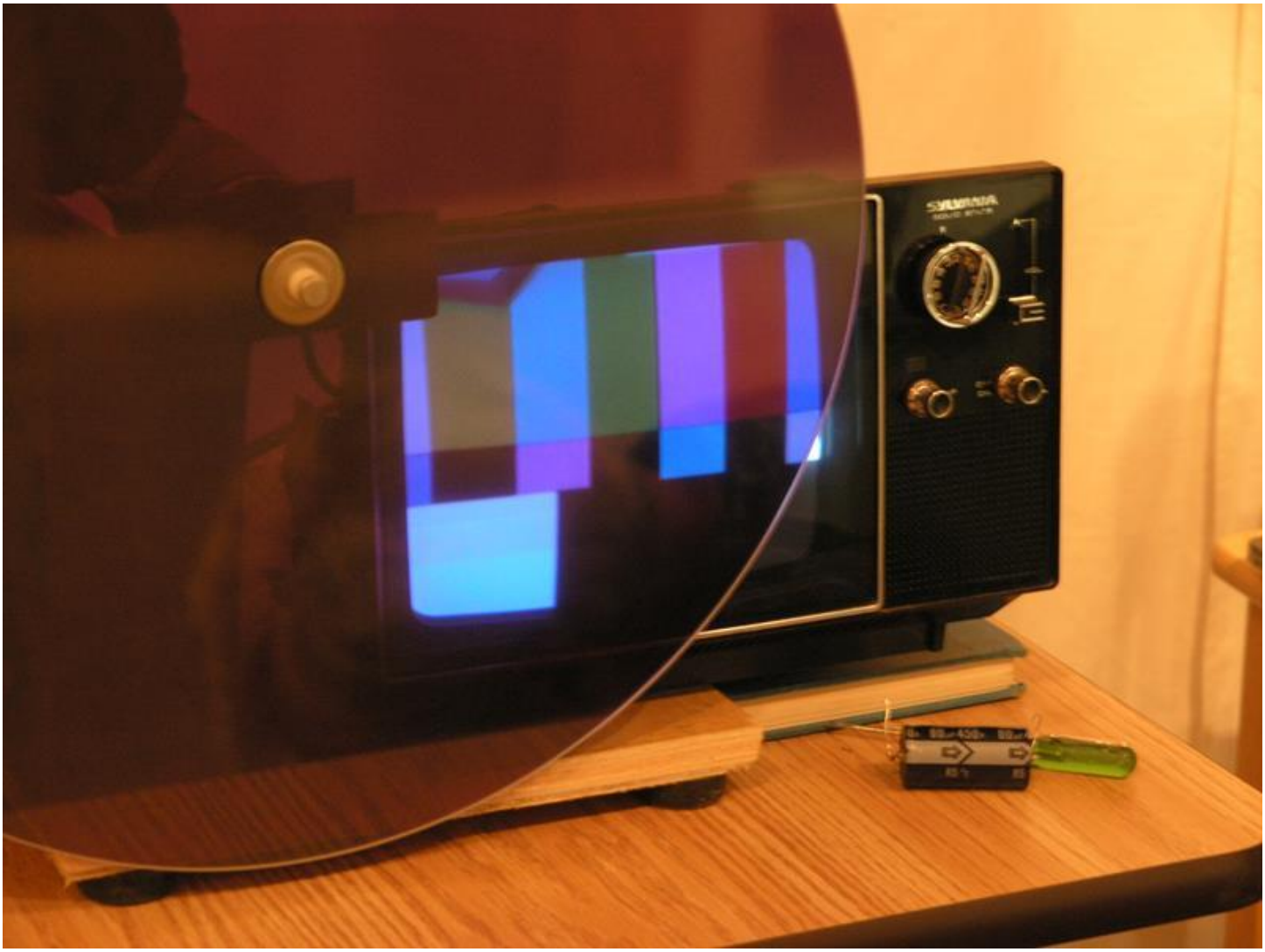
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All filaments, except the kinescope, shunt regulator and damper, are fused by either F102 or F103. These high voltage tubes are not fused since they are supplied from separate filament windings. This is necessary because the cathodes of the kinescope and damper are maintained at a large positive potential and to prevent arcing to the filament, these filament windings on the power transformer must be left ungrounded.

Vertical Centering — The action of the vertical centering control can best be described by referring to the schematic in FIGURE 5-40. Current flows through the centering control and R268 and R269. When the centering control is set at mid-range, there is an equal potential on both ends of the vertical deflection coils. Under this condition, no DC current flows through the yoke. If the control arm is moved to the right, current flows up through the yoke and the reverse takes place when the arm is moved to the left. The centering chokes maintain the yoke and output transformer (T110) above AC ground potential.

5-5. *Basic Theory of High Level Demodulation*

Since the 21CT662 demodulates color difference signals the use of high level demodulation is most desirable. With this technique the output of the demodulator is of sufficient amplitude to drive the grids of the tri-color kinescope directly without the use of intermediate amplifiers. Also by direct coupling the chrominance signals to the kinescope grids, the need for DC restoration is eliminated.

There are three methods by which high level demodulation may be accomplished. Two methods employ the use of three triode type tubes while the other method employs two triodes. The 21CT662 uses three tubes, however, for ease of understanding, all methods will be discussed.

One of the circuits which involves the use of three tubes is illustrated in FIGURE 5-41. The transmitted chrominance information is impressed across a transformer which is in series with the plate load resistor of each of the demodulators. The reference 3.58 mc CW signal is applied to the grids of these tubes. Tubes one (1), two (2) and three (3) demodulate B-Y, R-Y and G-Y signals respectively. Therefore the reference signal must be of the proper phase as indicated in FIGURE 5-41. The resistance and capacitance in the grid circuits are adjusted so that the time constant is long enough to permit the tube to operate class C and at the same time the resistance must be low enough to permit adequate plate current during positive swings on the grid. During positive swings of grid drive, the plate current should be sufficient to lower the plate voltage to about 25 volts. Also this condition should be such that it is relatively independent of a change in plate voltage. Therefore when a chrominance signal is applied to the plate, this signal is clamped at 25 volts when the tube conducts. When the tube is cutoff the plate voltage tends to rise and the value it attains depends upon the time constant of the tube output capacitance. At the same instant the tube cuts off, the plate voltage starts to rise and the chrominance signal on the plate adds to this voltage. FIGURE 5-42 illustrates this clamping action. If the chrominance signal on the plate is in phase with the grid drive, positive peaks of chrominance will occur at the same instant that the tube conducts. Thus

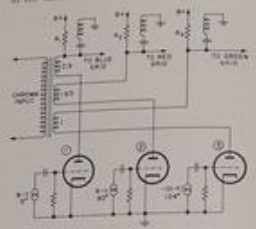


Figure 5-41 — High Level Demodulation

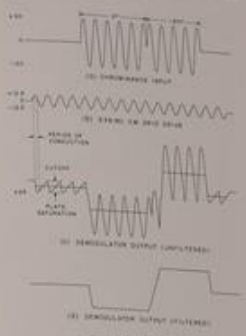


Figure 5-42 — In Phase Signals

the positive chrominance peaks are clamped at 25 volts. When the tube cuts off the chrominance signal is going negative while the plate voltage starts positive. However, the chrominance signal is greater in amplitude. Thus the plate voltage swings negative. Since the voltage developed across the plate load resistor is filtered to 3.58 mc, the average level of plate voltage change appears in the output. The plate is at a high impedance level to 3.58 mc, therefore the chrominance signals and the grid signal appear at this point.

When chrominance signal is 180 degrees out of phase with the grid signal, the negative peaks of the chrominance signal are clamped at 25 volts. This occurs since the plate signal is negative when the positive signal on the grid causes the tube to go into conduction. When the tube cuts off, the plate voltage begins to rise and at the same time, the chrominance signal swings

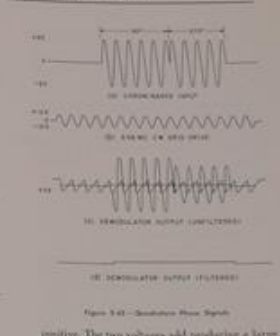


Figure 5-43 — Quadrature Phase Signals

positive. The two voltages add producing a large positive swing on the plate. This is illustrated in FIGURE 5-43. When the chrominance signal is in quadrature with the grid drive, the tube conducts while the signal on the plate is going through zero. Thus the zero points of the chrominance signal are clamped at 25 volts. Since the chrominance varies equally above and below this point, the average video output is zero as seen in FIGURE 5-43.

Chrominance signals which are between in phase and quadrature phase with the grid signal, produce a video output whose amplitude is proportional to the phase difference. Chrominance signals which are nearly in phase with the grid signal, produce more output than signals which are nearly in quadrature with the grid signal. Since the output of the demodulators drive the kinescope directly, utilizing no external matrix, there is one point for consideration; the chrominance signals are reduced in amplitude before transmission in order to prevent chrominance overshoots and this reduction in amplitude must

be recovered in the receiver.

This recovery can be accomplished in the turns ratio of the chrominance coupling transformer shown in FIGURE 5-41. Before transmission, the R-Y signal is reduced to .877. The B-Y signal is reduced to .493 and the G-Y signal is increased to 1.423. Therefore, the transformer turns ratio of the red, green and blue drives to each demodulator plate should be the reciprocal of the reductions or in the ratio of 1/.877 : 1/1.423 : 1/.493 respectively. With green as a reference, the ratio becomes:

$$\text{R-Y} : \text{B-Y} : \text{G-Y} = 1.63 : 2.9 : 1$$

5-6. "Bootstrap" High Level Demodulation

Another circuit which employs the use of only two triode demodulators is illustrated in FIGURE 5-44. It should be recalled that the G-Y signal may be obtained from the addition of —0.51 R-Y and —0.19 B-Y. Thus it is only necessary to demodulate R-Y and B-Y signals. A novel "bootstrap" technique is utilized where the G-Y signal is obtained from a common cathode resistor in the R-Y and B-Y demodulators. The plate loads and the cathode resistor are adjusted for the required R-Y, B-Y and G-Y signal amplitudes.

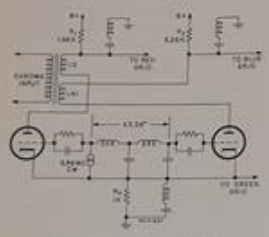


Figure 5-44 — "Bootstrap" High Level Demodulator

A simplified circuit of this system of demodulation is shown in FIGURE 5-45.

i_1 = current in R-Y demodulator
i_2 = current in B-Y demodulator
e_1 = voltage applied to R-Y plate (chrominance)
e_2 = voltage applied to B-Y plate (chrominance)
R_1 = plate load R-Y
R_2 = plate load B-Y
R_4 = common cathode resistance (G-Y load)

$E_{K-C} = i_1 R_1$
$E_{K-C} = i_2 R_2$
$E_{K-C} = (i_1 + i_2) R_4$

When R-Y = 0

$$\text{G-Y} = i_2 R_4$$

Since G-Y = —0.51 R-Y —0.19 B-Y and R-Y = 0

$$i_2 R_4 = -0.19 \text{ B-Y}$$

Then: $\frac{i_2 R_4}{i_2 R_2} = \frac{\text{B-Y}}{0.19 \text{ B-Y}}$

$$\frac{R_2}{R_4} = \frac{1}{0.19}$$

If R_4 = 1K, then R_2 = 5.26K.

When B-Y = 0

$$\text{G-Y} = i_1 R_4$$

Since G-Y = —0.51 R-Y —0.19 B-Y and B-Y = 0

$$i_1 R_4 = -0.51 \text{ R-Y}$$

Then: $\frac{i_1 R_1}{i_1 R_4} = \frac{\text{R-Y}}{0.51 \text{ R-Y}}$

$$\frac{R_1}{R_4} = \frac{1}{0.51}$$

If R_4 = 1K, then R_1 = 1.96K.

Therefore the ratio of plate load resistors equals:

$$\text{R-Y} : \text{B-Y} : \text{G-Y} = 1.96\text{K} : 5.26\text{K} : 1\text{K}$$

With the circuit arrangement shown in FIGURE 5-45, both R-Y and B-Y current flows in the common cathode resistor. When there is a chrominance signal applied to the plate of tube number 1, which is in quadrature with R-Y signals, there should be no R-Y output. A signal that is in quadrature with R-Y will cause maximum B-Y

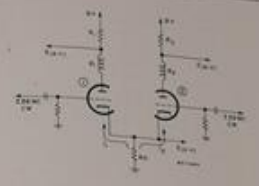


Figure 5-45 — Simplified "Bootstrap" Circuit

output. This causes B-Y current to flow through tube number 2 and the common cathode resistor. Any voltage across this resistor is present at the B-Y output. Therefore signals in quadrature with B-Y signals are present in the R-Y output.

This condition is highly undesirable and steps are taken to minimize resulting cross-talk. By changing the phase of the 3.58 mc CW signal applied to the grid of tube number 1 so that it is not in phase with R-Y but leans slightly toward B-Y phase, an equal and opposite B-Y current will flow through tube number 1 which will cancel the B-Y signal present at the R-Y output due to the common cathode resistor. This phase is critically adjusted so that only R-Y information is present in the output. Since this same condition is present in the B-Y section, its applied CW phase is also critically adjusted for R-Y signal cancellation.

In order to calculate the phase requirements, we must assume that the demodulators are perfect switches:

Then:

$$e_1 = (\text{G-Y}) - (\text{R-Y})$$
$$e_2 = (\text{G-Y}) - (\text{B-Y})$$

The phase angle requirements of demodulators 1 and 2 can be calculated by finding e_1 and e_2 in terms of R-Y and B-Y. It is known from previous calculations that G-Y equals —0.51 R-Y —0.19 B-Y. Substituting these values in the e_1 and e_2 formulas we find that:

$$e_1 = (-0.51 \text{ R-Y} - 0.19 \text{ B-Y}) - (\text{R-Y})$$
$$= -1.51 \text{ R-Y} - 0.19 \text{ B-Y}$$
$$e_2 = (-0.51 \text{ R-Y} - 0.19 \text{ B-Y}) - (\text{B-Y})$$
$$= -0.51 \text{ R-Y} - 1.19 \text{ B-Y}$$

As discussed in the previous demodulator circuit which employs the use of three tubes, the amplitudes of R-Y and B-Y must be increased by the reciprocal of .877 and .493 respectively. Therefore:

$$e_1 = \frac{-1.51 \text{ R-Y}}{.877} - \frac{0.19 \text{ B-Y}}{.493}$$
$$= -1.72 \text{ R-Y} - .386 \text{ B-Y}$$

From FIGURE 5-46:

$$\tan \theta_1 = \frac{.386}{1.72} = .244$$
$$\theta_1 = 12.6°$$

Also:

$$e_2 = \frac{-0.51 \text{ R-Y}}{.877} - \frac{1.19 \text{ B-Y}}{.493}$$
$$= -.582 \text{ R-Y} - 2.42 \text{ B-Y}$$

Figure 5-46 — Vector Representation of Demodulator 1

From FIGURE 5-G:

$$\sin \Theta_1 = \frac{.502}{2.42} = .21$$

$$\Theta_1 = 13.5^\circ$$

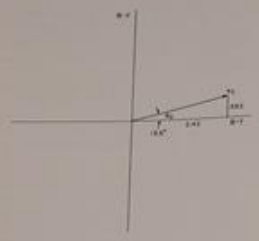


FIGURE 5-G — Vector Representation of Demodulator 2

The angle Θ_2 can be determined by adding Θ_1 and Θ_2 and subtracting this sum from 90° as shown in FIGURE 5-H.

Thus:

$$\Theta_2 = 90^\circ - (\Theta_1 + \Theta_2)$$
$$= 90^\circ - (12.6^\circ + 13.5^\circ)$$
$$= 90^\circ - 26.1^\circ$$
$$= 63.9^\circ.$$

The amplitude of e_1 and e_2 shown in FIGURES 5-46 and 5-47 can be calculated as follows:

$$e_1 = \frac{1.72}{\cos \Theta_1} \qquad e_2 = \frac{2.42}{\cos \Theta_2}$$

$$= \frac{1.72}{\cos 12.6^\circ} \qquad = \frac{2.42}{\cos 13.5^\circ}$$

$$= 1.76 \qquad = 2.49$$

The ratio of e_1 to e_2 is:

$$e_1 : e_2 = 1.76 : 2.49$$

$$e_1 : e_2 = 1 : 1.41$$

This unequal drive requirement of the two demodulators can be adjusted in the turns ratio

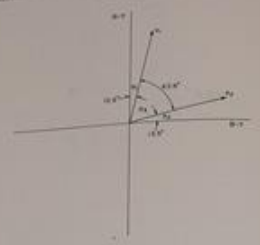


FIGURE 5-H — Vector Representation of the "Resultant" High Level Demodulation

of the chrominance coupling transformer as shown in FIGURE 5-44.

5-7. *Demodulation in the 21CT662 RCA Color Television Receiver*

The 21CT662 utilizes a somewhat modified circuit whereas it employs the use of three triodes. Two of the triodes are used to demodulate R-Y and G-Y color difference signals and the other triode is used as a combined matrix and phase inverter for obtaining the B-Y signal. All of these color difference signals are of the high level type and drive the kinescope directly. R-Y and G-Y signals are demodulated rather than some combination with B-Y since a B-Y demodulator requires a greater chrominance drive than either R-Y or G-Y. This is due to the fact that B-Y is reduced to .493 before transmission, whereas R-Y and G-Y are reduced to .877 and 1.432 respectively. The chrominance drive to the demodulators must be the reciprocal of these values. A B-Y signal can easily be obtained by matrixing $-2.73R\text{-}Y - 5.63G\text{-}Y$. However, since positive R-Y and G-Y signals are demodulated, they must be matrixed, then phase

inverted to form a positive B-Y signal. A simplified drawing of the demodulator circuit used in the 21CT662 is illustrated in FIGURE 5-35. The chrominance drive is applied to the demodulators by means of a center tapped chrominance coupling transformer. The G-Y demodulator requires the least drive therefore it is driven from the center tap of the transformer. Resistive loads are placed across the secondary of this transformer in order to provide the required bandwidth. Positive R-Y and G-Y signals are developed across their respective demodulator plate load resistors. These low pass filters, L129 and C239 in the R-Y output, L130 and C241 in the G-Y output and L131 and C247 in the B-Y output, reject all 3.58 mc carrier and sideband information and pass the lower frequency color difference signals on the grids of the tricolor kinescope. To provide the B-Y signal, the outputs of the R-Y and G-Y demodulators are fed into a resistive matrix composed of R256 and R203. The output of this matrix is phase inverted and amplified by the B-Y phase inverter tube. Since the outputs of the demodulators are direct coupled through the matrix to the grid of the phase inverter, a positive DC bias voltage is placed on this grid. To bias the tube properly a larger positive voltage is applied to the cathode by means of a voltage divider network which consists of R296 and R297.

Operation of the demodulators and B-Y matrix can be checked with the aid of a color bar generator. The color receiver and the color bar generator should first be adjusted for a normal color bar pattern on the face of the kinescope. To check R-Y phase, connect a 100K resistor from each of the blue and green grids to ground. The red bar pattern observed should be similar to the one illustrated in FIGURE 5-49. The sixth (B-Y) bar, counting from the left, should have the same brightness as the background. The burst discriminator transformer (T112) may be adjusted to meet this condition with the HUE control set at the center of its range. To check B-Y phase, remove the 100K resistor from the blue grid and

FIGURE 5-49 — Red Matrix — Green and Blue Missing

FIGURE 5-50 — Blue Matrix — Red and Green Missing

FIGURE 5-51 — Green Matrix — Red and Blue Missing

Adjust the blue amplitude control until the horizontal blue line is approximately straight. Adjust the red and green horizontal tilt controls so that the red and green lines are symmetrical about the vertical blue lines. This condition is illustrated in FIGURE 5-19.

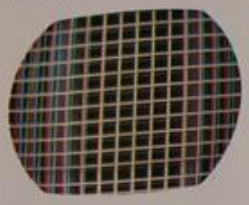


Figure 5-19 — Red and Green Horizontal Phase Control — Amplitude Maximum

Adjust the red and green horizontal amplitude controls to make the vertical red and green lines across the horizontal axis of the raster equally spaced or coincident with the vertical blue lines. Readjust the blue horizontal amplitude and phase controls to make the horizontal blue line, along the horizontal axis of the raster, parallel or coincident with the associated red and green lines. Adjust the four static converging-magnets to statically converge the three patterns in the center of the screen.

Figure 5-20 — Good Convergence

If the overall resultant convergence is not as good as the circuit is capable of producing, a step by step review of the set-up procedure will indicate what readjustments must be made to improve over-all convergence. FIGURE 5-20 illustrates good overall convergence.

Purity—Positioning of the electron beam paths so as to obtain pure primary fields is accomplished by adjustment of the yoke position, purifying magnet and magnetic-field equalizer. As with any shadow mask type of picture tube, it is necessary that each of the three beams approach the shadow mask at the proper angle if it is to excite only the proper dot in the trio. The color kinescope is so constructed that if a beam passes through a preselected "center of deflection" at the yoke and follows straight paths from this point to the phosphor screen, it will strike phosphor dots of only one color as it is deflected over the entire screen. The aim of the purity adjustment is to position the three beams in the tube neck so that they pass through these centers, and to position the yoke so that deflection appears to occur at the selected points of deflection.

Final adjustment in color purity (equalizer adjustment) should not be attempted until optimum static and dynamic convergence has been obtained. As with earlier color tubes, when making preliminary purity adjustments, the purifying magnet is adjusted and the yoke is positioned along the neck of the tube while observing a red field (contrast and color controls minimum, red screen and brightness controls maximum and green and blue screen controls minimum). The equalizer magnets should be retracted into their housings (pulled back from the picture tube) before making these adjustments.

A microscope of 15 to 20 power is very useful in making purity adjustments. Such a magnifier permits observation of the actual area of the

phosphor dots being excited. When difficulty occurs in obtaining good purity, an analysis of the type of beam displacement relative to the centers of the phosphor dots will point out the type of correction that should be made.

Precautions should be taken to keep the kinescope away from magnetic fields which might magnetize the metal shell and internal parts and thus produce localized areas of color impurity and raster distortion. FIGURE 5-21 illustrates the effects of extraneous magnetic fields on a kinescope which has been properly adjusted for a gray raster. Notice the extreme contamination at the center edges of the raster.

Figure 5-21 — Effects of Extraneous Magnetic Fields

As a precautionary measure the tube should be degaussed in its *final operating* position, in the receiver, before proceeding with purity adjustments. This degaussing may be accomplished by means of a suitable degaussing coil. This coil should be fairly large, 12 to 14 inches in diameter. An illustration of a typical degaussing coil is shown in FIGURE 5-22.

Before applying power to the degaussing coil, the equalizer magnets should be retracted into their housings. It is not necessary to turn the color receiver off during the degaussing process. Plug the degaussing coil power cord into a 115 volt 60 cycle source. Hold the coil close to the

Figure 5-22 — Degaussing Coil

faceplate with the plane of the coil parallel to the faceplate. After holding it in this position for several seconds, slowly back away from the set about 6 feet and turn the degaussing coil so that the plane of the coil is perpendicular to the face of the kinescope. Disconnect the line cord. After degaussing, purity adjustments may be made.

The normal sequence involves first the static convergence adjustment, next the purifying-magnet adjustment, and then adjustment in the axial position of the deflecting yoke. The yoke is moved axially toward the converging-magnet assembly as far as it will go.

Figure 5-23 — Uniform Red Field in Center of Screen

The convergence in the center of the screen should be adjusted by means of the static-convergence controls and by adjustment of the blue-positioning magnet. With the red beam on and with no video signal applied, the purifying magnet should be rotated on the tube neck while its magnetic-field strength is varied until a uniform red field appears in the center of the screen as illustrated in FIGURE 5-23.

In the central area of the viewing screen, the position of the excited area of the phosphor dot, as illustrated in FIGURE 5-24a, may be observed with a microscope. Rotational adjustment of the purifying magnet affects the direction in which the excited area moves, while adjustment of its field strength moves the beam in that direction. The purifying magnet should be adjusted in the above manner until the excited area is in the middle of the phosphor dot. This position of the excited area is referred to as "center landing."

Slide the deflecting yoke axially on its supports to produce the most uniform red field. The green and blue fields should now be checked separately for color purity. A compromise in adjustment settings should be made if necessary to give the best red, blue and green field purity in the central region of the screen. Center convergence should be checked before and after each purity adjustment.

The relative displacements of the excited areas, with respect to the phosphor dots, may be observed with a microscope at the top center and bottom center of the raster when adjusting the yoke. If the displacements have radial components (see FIGURE 5-24b), the yoke should be adjusted axially until the excited areas of the phosphor dots are centered or have only a tangential displacement component as shown in FIGURE 5-24c.

Corrections in purity for extraneous magnetic fields may now be made using the magnetic-field equalizer assembly. With the red beam on and with no video signal applied, the color equalizer magnets should be adjusted to obtain color purity over the entire screen. Purity is obtained by shifting the beam in a radial and/or tangential direction by the required amount. Next, adjust the brightness of the red, green and blue fields to obtain a white raster. The equalizer magnets are then readjusted to obtain best white uniformity over the entire screen. In addition, it may be

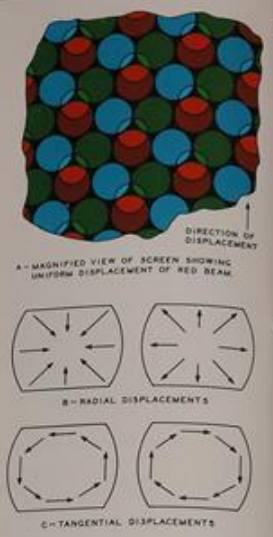


Figure 5-24 — Purity Displacement Diagrams

necessary to readjust the yoke and purifying magnet slightly. Convergence of the three beams should be checked and readjusted if necessary. It should be noted that the yoke position and magnetic-field equalizer adjustments have negligible effects on convergence.

The area of the screen adjacent to each of the sections of the equalizer may be observed to advantage with a microscope when the respective equalizer controls are adjusted to obtain optimum white. The electron beams should be landing entirely on their respective phosphor dots. When such is the case, the position of the excited area of the phosphor dot is referred to as "full landing." If difficulty in obtaining optimum color purity and white uniformity is still encountered, a compromise adjustment of equalizer, purifying magnet, and yoke will possibly be helpful.

5-3. *Block Diagram Description of the 21CT662 RCA Color Television Receiver*

The 21" color television receiver can be divided into thirty (30) blocks. These blocks are illustrated in block diagram form on a pull-out in the rear section of this lesson. Included on the block diagram are the oscilloscope presentations of the bandpass waveforms of the chrominance and luminance amplifier circuits.

A switch type RF tuner in this receiver replaces the turret type used in earlier RCA color television receivers. Special circuits are incorporated for counteracting the tendency of the tuner to detune with a change in RF bias. The frequency response of the tuner is maintained between close limits for a large range of RF biases.

The tuner is linked coupled to a three stage picture IF amplifier. From FIGURE 5-25, it can be seen that the IF response is flat to 42.75 mc. Below 42.75 mc, the response falls off to 10 per cent at the extreme end (41.75 mc) of the color bandpass. This places the color sub-carrier (42.17 mc) at the 50 percent response point. As

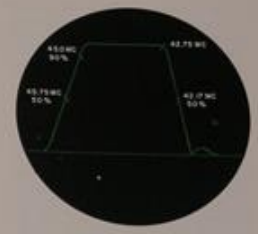


Figure 5-25 — Picture IF Response

a result, the color frequencies appear with reduced amplitude at the output of the picture IF. The correct amplitude relationship between chrominance and luminance frequencies is restored in the chrominance amplifiers.

The output of the picture IF is applied to the 1N60 crystal detector. The video output developed by the crystal detector is DC coupled to the first video amplifier stage.

The first video amplifier provides signal information to five (5) other circuits. The luminance signal is obtained from the cathode, and the sync, AGC, sound and chrominance signals from the plate of the first video amplifier. The luminance signal is amplified in a second video stage which is DC coupled to the cathodes of the tricolor kinescope.

The sound IF discriminator and audio amplifiers are of conventional design. The cathode circuit of the audio output stage provides the +140 volts plate supply for the picture IF, sync and sound stages.

A noise inverter stage is utilized to immunize sync and AGC from noise disturbances. Composite video, with sync negative, is applied to the cathode of this stage. The inverter is biased

Figure 4-42 — Color Bar Pattern with Q Signal Missing

Figure 4-43 — Color Bar Pattern with I Signal Missing

Figure 4-44 — Blue Matrix, Red and Green Guns Blanked

Phase and Matrix Adjustment With the Kinescope — If an oscilloscope is not available, the phase and matrix adjustments may be made with reasonable accuracy using the kinescope as an indicating device.

Connect the Color Bar Generator and adjust the color receiver as described in the preceding section. Set the Hue and Color controls to mid-position. Remove the Q phase splitter tube. Readjust the Brightness and Contrast controls if necessary. The color-bar pattern remaining on the kinescope contains no Q information. Adjust the Hue control, and the Burst-tuning coil if necessary, to make the center of the fifth bar the same as the background and without color, as shown in FIGURE 4-42. Replace the Q phase splitter tube.

Remove the I phase splitter tube. Adjust only the Brightness control if necessary. The color-bar pattern remaining on the kinescope contains no I information. Adjust the quadrature transformer (top) until the centers of the second and eighth bars are without color and equal to the background, as shown in FIGURE 4-43. Replace the I phase splitter tube. This completes the I and Q phase adjustments.

To check the blue grid, short the red and green kinescope grids to ground. Adjust the I gain control until the centers of the third and ninth bars have approximately the same blue brightness level, as shown in FIGURE 4-44.

Figure 4-45 — Green Matrix, Red and Blue Guns Blanked

To check the green grid, short the blue and red grids to ground. The centers of the first and seventh bars should have the same green brightness level, as shown in FIGURE 4-45.

To check the red grid, short the blue and green grids to ground. The sixth bar should have the same red brightness level as the background, as shown in FIGURE 4-46.

Phase and Matrix Adjustments with Transmitted Color Bar Signals — On occasion a transmitted color bar pattern will be available for testing purposes. Test pattern air time of course is dependent on local station option, but can be used to advantage when available. At the time of this writing, no test pattern for color has been universally accepted or standardized. The pattern covered here is the NBC color bar pattern illustrated in FIGURE 4-47. This pattern is divided into upper and lower parts. The upper half is a series of color bars, from left to right, green, yellow, red, magenta, blue, cyan and green. The lower half is a series of chrominance and brightness signals, from left to right, $-I$, $-I$ and $+Q$, $+Q$, black, and white. FIGURE 4-48 illustrates how this pattern appears on an oscilloscope at the second detector of a receiver. Since the top and bottom of the test pattern are different but in the same picture scan area, the two halves of the pattern are superimposed in the oscilloscope presentation. The various bars of the pattern are indicated in FIGURE 4-48.

Figure 4-46 — Red Matrix, Blue and Green Guns Blanked

Figure 4-47 — NBC Color Bar Test Pattern

In checking chrominance phase and matrix adjustments using the transmitted color bar signal, the phase relationships of the receiver chrominance circuits must first be correct before the matrix can be adjusted. To check receiver chrominance phase, connect an oscilloscope to the $+I$ line into the matrix. The waveform should appear as in FIGURE 4-49a. If the I phase is adjusted properly (with the Hue control at midposition), there will be no trace other than the base line under the red bar response (the third bar). If a double trace is present, adjust the burst take-off transformer until one trace disappears into the base line. This eliminates Q information from the I channel. To check Q phase, switch the oscilloscope to the $+Q$ line. The trace

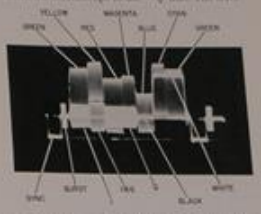


Figure 4-48 — Oscilloscope Waveforms of the NBC Color Bar Pattern

Figure 4-2 — Normal Color Bar Pattern

demodulation, and color matrix sections of the receiver and enables us to make adjustments of these sections. Of course, if a proper transmitted color bar pattern is available, it may be used.

4-3. *Installation of Kinescope and Related Components*

Identification of Red, Green and Blue Guns for Proper Placement — The production of correct colors does not depend on any particular orientation of the kinescope. However, the convergence adjustment procedure depends upon knowing the location of the various guns in the tricolor kinescope. It is recommended that the kinescope be installed so that the blue gun is on top.

To determine the proper position of the kinescope and permit identification of the three electron guns, the best procedure is to view the kinescope socket from the rear of the tube and rotate the tube until the socket key appears to the right and just above the center of the socket, so that the key points to about two o'clock, as shown in FIGURE 4-6. In this position, one kinescope gun will appear directly at the top of the neck, and the other two guns will be on a horizontal line below. In this position, the internal mask is correctly aligned. Viewed from the rear, the blue gun appears on top, red appears to the right, and green to the left. This is the correct position of the kinescope when finally installed in the cabinet.

Figure 4-7 — Component Parts of the Kinescope

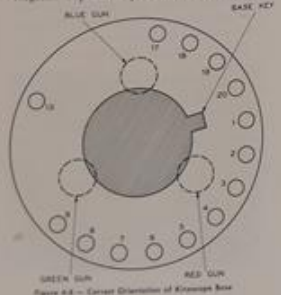


Figure 4-6 — Correct Orientation of Kinescope Base

The Kinescope Assembly — It is recommended that the high-voltage connector, high-voltage insulator, cone shield, and retaining ring be assembled on the kinescope. Then this assembly should be installed, as a unit, in the receiver. The second anode connector should be clipped onto the kinescope anode ring at the top, approximately in line with the blue gun, and with the lead running to the right along the anode ring.

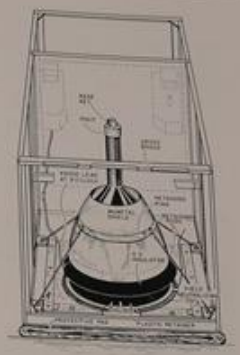


Figure 4-8 — Kinescope Correctly Mounted in Cabinet

The anode insulator should be slipped under the anode lead, and then drawn all the way around the kinescope completely to cover the anode ring. With these components properly installed, the insulator will end and make the anode lead available on the right of the kinescope in a position convenient to the high-voltage supply. FIGURE 4-7 shows a grouping of the kinescope and its components.

To eliminate the possibility of having the electron beams deflected by extraneous magnetic fields, install the cone shield over the bell of the kinescope with the rim of the shield over the edge of the insulator so that it holds the insulator in place. Be sure that the grounding spring inside the shield contacts the aquadag kinescope coating to ensure that the coating will be grounded.

Install the retaining ring over the cone shield with brackets positioned so they can receive the retaining rods. The complete kinescope assembly is shown in FIGURE 4-8.

Installation in Cabinet — The easiest way to install the kinescope is to lay the cabinet face down on a thick, quilted pad, taking care to protect it from scratching or other damage. The pad should be arranged to keep the control knobs clear of the floor. The kinescope assembly, complete with anode lead, insulator, shield, and retaining ring, should be placed in the cabinet and rested on the front cabinet mask, as shown in FIGURE 4-8. Be sure that the blue gun faces the cabinet top. The retaining rods should be fastened to the loops in the cabinet and inserted in the slots of the retaining ring. They should then be tightened *finger tight*. After raising the cabinet to an upright position, inspect the kinescope face to assure that its position is correct. Should minor correction be necessary, loosen the retaining rods and rotate the kinescope to its correct position. After kinescope adjustment, the rods should again be made finger tight.

The grounding spring attached to the chassis should be adjusted to make secure contact with the kinescope shield.

Deflection-Yoke Position — The deflection yoke is supported completely separate from the kinescope by a cross-bar extending from the cabinet sides. The front edge of the yoke should be about

Figure 4-9 — Installing the Yoke and Neck Shield Assembly

4-1. *Operation and Function of Front Panel Controls*

With minor exceptions, the color receiver is operated like a black-and-white set. In general, the receiver is adjusted to obtain a good black-and-white picture, and then color is added to the picture. The following procedure is suggested for putting the receiver in operation.

Turn the Color control to its extreme counterclockwise position. This turns off the color and allows the tuning of the desired station in the regular manner. The Contrast, Brightness, Volume, Tone, Horizontal and Vertical Hold, and Channel Selector controls are operated exactly as for a black-and-white receiver. The Fine Tuning control, however, requires careful adjustment. Although the color receiver uses intercarrier sound so that tuning is not critical, an interference pattern will appear in the picture when the fine tuning is misadjusted because of the beat note produced between the 4.5 MC sound signal and the chrominance subcarrier. This 920 KC pattern is minimized when the traps included in the receiver are rejecting the 41.25 MC sound IF signal. Therefore, careful oscillator or fine-tuning adjustment is required. The Fine Tuning control should be turned clockwise until the picture disappears. Then the control should be turned counterclockwise until the picture clears and the beat pattern diminishes, and additional rotation will cause the interference to appear again. This center point of minimum 920 KC beat is the correct fine tuning point. Extreme counterclockwise rotation of the Fine Tuning control will also tune the receiver to a point where interference is not visible and the tuning is very broad. However, tuning to this point will distort picture response and prevent color reception. Just as in black-and-white, we must tune close to the point where additional clockwise rotation of the Fine Tuning control destroys the picture.

The DC Focus control and the DC Convergence controls are brought out at the side of the receiver and equipped with knobs for use by the customer if needed. The Focus control is adjusted for clearest picture detail, and the Convergence control is adjusted for minimum color fringing in the center of the picture. The receiver is now adjusted to reproduce a clear, contrasting black-and-white picture.

For color reception, the setting of the Color control is adjusted until a normal saturation of color appears in place of the gray tones. The flesh tones should be observed carefully; if they do not have the proper tint, the Hue control should be adjusted until they do. The Color control may now require readjustment. With the exception, then, of the Hue and Color controls, and a little more careful attention to the fine tuning adjustment, the receiver has been tuned with conventional black-and-white techniques.

Figure 4-1 — Fastening Deflection Adjustments

Figure 4-2 — Improper Convergence on a Black-and-White Picture

Effect of Misadjusted Front-Panel Controls—The technician should be familiar with the picture defects that may be caused by misadjusted front-panel controls. Proper adjustment of operating controls can be checked in the following manner. Turn the Color control fully counterclockwise. A normal black-and-white picture with good definition should be present. If the Fine Tuning control is improperly adjusted—picture IF carrier too low in frequency—definition will be poor. The Fine Tuning control should be readjusted for maximum definition and minimum interference pattern. Turn the Color control until color appears in the picture; do not turn it to an excessively high position or it will cause "color overload"—extremely saturated colors and low color definition. Improper hue adjustment makes unpleasant skin and flesh reproduction and will be apparent when viewing commercials showing standard-brand products. Adjustment should be made to create a pleasing reproduction of the televised objects. The effect of improper DC convergence setting on a black-and-white picture is shown in FIGURE 4-3. Minimum color fringing in the center of the picture, particularly in large areas, should be obtained with the Convergence control.

4-2. *Test Equipment Required for Receiver Adjustment*

The adjustment of color television receivers is greatly facilitated by two new types of instruments the *RCA WR-36A Dot-Bar Generator* and the *RCA WR-61A Color Bar Generator*. Before discussing these instruments, we will first outline the major steps in the adjustment and setup of the color receiver and describe the specialized signals needed for certain of these adjustments.

The major steps in the adjustment and setup of the receivers are as follows:

1. Picture size, linearity, hold, and other black-and-white adjustments.
2. Color purity adjustments.
3. Convergence adjustments.
4. Color balance or grey scale adjustments.
5. Matrix adjustments.

The Dot Generator — The *RCA WR-36A Dot Bar Generator* supplies a signal that produces on the screen a pattern of white dots on a black background, an example of which is shown in FIGURE 4-4. This pattern is essential for rapid, accurate convergence adjustments, and is very useful for making linearity adjustments and the grey scale adjustments. The technician may be already familiar with the use of a dot generator for checking linearity on black-and-white receivers. On a color receiver, correct size and linearity adjustments are even more important. The size and linearity adjustments will affect the purity and convergence adjustments.

Although any black-and-white transmission may be used to make the linearity adjustment, motion in the picture will make this adjustment difficult. If a transmitted test pattern is not available, the stationary dot pattern will be very helpful for adjusting linearity as well as convergence. Picture size and gray scale adjustments are best made with a black-and-white picture.

Color Bar Generator—The *RCA WR-61A Color Bar Generator* supplies a signal that appears on the kinescope screen as a series of vertical bars of various primary and secondary colors, and also provides a burst pulse and a horizontal sync pulse for the color receiver. A typical bar generator pattern is shown in FIGURE 4-5. The application of such a signal to the receiver allows us to check the operation of the color sync, color

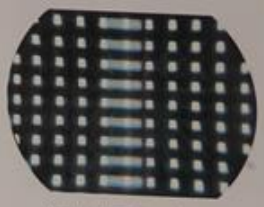


Figure 4-4 — Properly Converged Dot Pattern

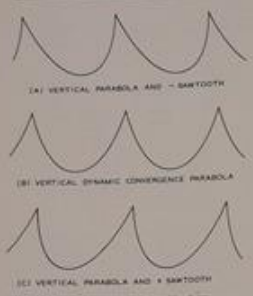


Figure 3-46 – Vertical Convergence Waveforms

coil is rotated about the neck of the tube until the correct position is found. The magnetic field of this coil produces a deflection of the raster similar to centering in any desired direction. The centering of the raster with the centering controls is accomplished without affecting purity by varying the required DC currents through the horizontal and vertical-yoke coils.

The earth's magnetic field will deflect the beam of a cathode-ray tube. In a color tube, this not only shifts centering but also changes purity. To minimize this effect, both a neck shield and a cone shield are used as previously described in Lesson 1. In a north or south orientation, a component of the earth's field will pass lengthwise through the tube and cause beam displacements. This component of the earth's field can be neutralized by means of the field neutralizing coil at the rim of the kinescope. Changing the direction of orientation of the receiver may affect this adjustment.

Color Balance—As was explained in the lesson on Basic Color Principles, specific ratios of light radiations of the red, blue and green phosphors are required to produce the desired white. If a satisfactory gray scale is to be obtained, these ratios must be maintained for all light levels. For any particular kinescope, the ratio of gun currents must be kept constant. This will vary among kinescopes due to variations in the efficiency of the phosphors.

In adjusting the kinescope and video drives to obtain the desired current ratios, this circuit operates as follows: the cut-off of each of the three guns is adjusted to coincide at maximum background (least negative bias) setting by varying the screen-grid voltage of each gun. This is done for a low-brightness white level. Video drive is then added, and the blue and green video gain controls are adjusted to produce a monochrome picture with desired shade of white. The master background control is then reduced to obtain a darker (just visible) picture, and the blue and green background controls are adjusted so that the change in their DC voltages is proportional to their video drives, so that a picture with uniform gray scale is maintained.

The reasons for operating the tri-color kinescope in this manner can be better understood by referring to FIGURE 3-47. This is a plot of gun current versus grid voltage. For simplicity, the characteristic curves are shown as straight lines. The G_m of the three guns may be slightly different, and therefore three curves are shown, labeled low G_m, normal G_m, and high G_m. First, assume each gun needs to produce the same current to make white. At some dark gray level, say I_1, the screen voltages are adjusted to obtain the same gun current for a given grid voltage. In order to match the three guns, it is necessary to drive the low G_m gun with e_1 volts, the normal G_m gun with e_2 volts, and, G_m gun with e_3 volts. With the present phosphors in the tri-color tube, it is necessary for the beam current in the red gun to be twice that of the blue or the green gun to produce white. This is accomplished by raising the red screen-grid voltage slightly for dark gray and increasing its video drive to match the highlights. A still better match is obtained by

slightly degenerating the red gun. This is done by resistor 2R154 in the cathode of the red gun.

The background control must operate so as to keep the highlights neutral (without color tinting), when it is reduced. This means that the background control must bias off the red gun at a faster rate than the blue or green. This is accomplished by adjusting the amount of bias fed to the blue and green guns. The schematic of this circuit is shown in FIGURE 3-48. The operation of the circuit is as follows: the red grid is connected to the center arm of the master-background control. When the master-background control is at point C, center arms of the three controls are at the same potential. As soon as the center arm of the master-background control is moved toward ground, it becomes more negative than either D1 or D2, and the red grid will become negative more rapidly than the other two grids.

To allow as much freedom as possible for adjustment of the background control without being

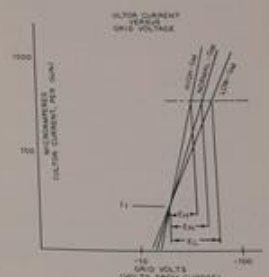


Figure 3-47 – Tri-color Kinescope Characteristic Curves

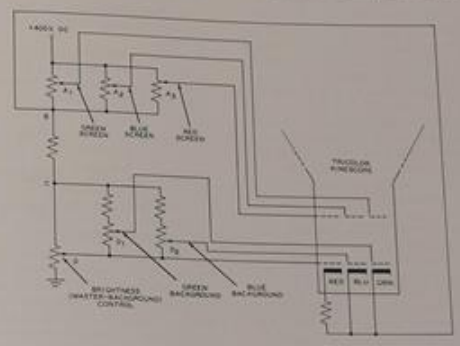


Figure 3-48 – Kinescope Control Circuits

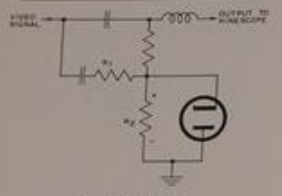


Figure 3-34 — DC Restorer

3-3. *Color Synchronization Section*

This portion of a color receiver has an entirely new function and is required only for color television operation. The purpose of the color synchronizing circuits is to recreate a 3.58 MC subcarrier signal whose frequency and phase is exactly that of the subcarrier signal that was originally used at the signal source. Once the locally generated subcarrier signal is correctly established, it can then be reinserted in the received chrominance sideband signals to replace the subcarrier that was suppressed before transmission. This of course is a necessary step for color demodulation, which has already been covered.

The color sync section consists of a 3.58 MC crystal oscillator and an APC (Automatic Phase Control) circuit to control its frequency and phase, plus the necessary 90 degree phase-shifting circuit to obtain two quadrature signals for the demodulators. The APC portion is similar in principle to some AFC systems already encountered in television, such as the RCA Synchrolock.

The color sync section is shown in block diagram form in FIGURE 3-35. Each tube is identified by its number as it appears on the complete receiver schematic diagram. The color killer is included in the diagram because it operates in conjunction with the phase detector; however, it has no APC function.

Referring to the complete receiver schematic diagram, at the first video amplifier V114, burst is coupled from the plate circuit by the small coupling capacitor 2C187 into a parallel-tuned circuit that is connected to the grid of the burst amplifier V129A. From the cathode of this same video amplifier, chrominance information is fed

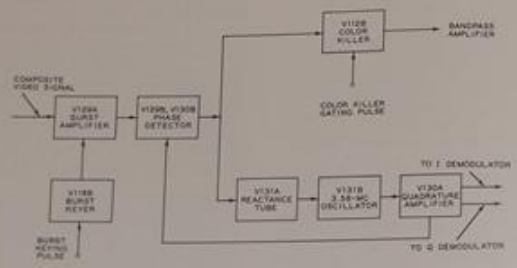


Figure 3-35 — Block Diagram of the Color Sync Section

to the band-pass amplifier V116A. At this point, the burst becomes separated from the chrominance information, and the absolute phase relation between the two is lost. This at first may appear to be a disadvantage and to defeat the purpose of the burst. However, this is not the case, as it provides a means for shifting the phase of the burst relative to the color picture content for the purpose of controlling the colors produced by the receiver.

The action of phase-shifting the burst is accomplished by the hue control. FIGURE 3-36 shows the selectivity curve and phase characteristics of a parallel-tuned circuit such as is made up of the burst amplifier grid coil and the variable capacitor in shunt with it. If this circuit is peaked so that maximum response occurs at the subcarrier frequency, then there will be a certain fixed phase shift through this network. This fixed phase shift may be considered as a starting point, or zero phase shift. A change of the hue-control setting so as to increase the capacitance would, in effect, lower the peak frequency of the tuned circuit. This is shown by the dotted-line curves. In this way, the phase of the subcarrier has been shifted so as to lead approximately 45 degrees, along with reduction in amplitude change of 30 per cent. In a similar way, a decrease of capacitance would raise the peak frequency above the subcarrier to give a phase shift in the opposite direction. Thus, the phase of the burst signal passing through the network may be shifted ahead or behind to control the reproduced colors.

At the grid of the burst amplifier, high-frequency video information exists along with the burst. However, for color APC purposes, only the burst is of importance. Since it occurs in the signal only after each horizontal-sync pulse, it may be separated by allowing the burst amplifier to conduct only at the time when burst appears at the grid; that is, the burst amplifier conducts immediately following each horizontal sync pulse. To help accomplish this, the keyer tube V116B has its cathode common with the

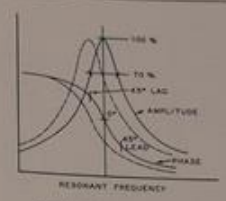


Figure 3-36 — Action of the Hue Control

burst amplifier V129A. The keyer stage is normally conducting to the extent that the voltage developed across the common cathode resistor is sufficiently positive to cut off the burst amplifier V129A. A pulse is derived from the horizontal-output transformer and delayed by the RC network 2R295 and 2C247 until it occurs at the same time that burst appears in the signal. This large, negative horizontal pulse is applied to the keyer-tube grid which causes this tube to stop conducting for the duration of the pulse. The plate of the keyer will have a positive-going pulse with a flat top caused by the tube being held at cut-off. This positive pulse is applied to the grid of the burst amplifier, allowing it to conduct and amplify the burst. In this manner, the burst is gated out of the composite signal, insuring good color sync as long as the receiver remains in horizontal synchronization.

Now that the burst has been separated from the signal, it remains to be shown how the eight cycles of the 3.58 MC subcarrier signal produce a locally generated subcarrier signal of the correct frequency and phase.

Phase Detector — Referring back to FIGURE 3-35, we see that a closed loop is made up of the phase detector, reactance tube, 3.58 MC oscillator, and quadrature 3.58 MC amplifier. This arrangement operates in the following manner. The locally generated 3.58 MC signal originates

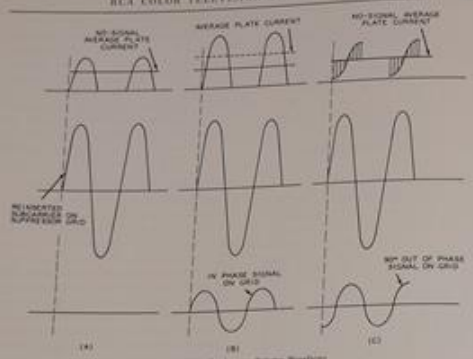


Figure 3-29 — Synchronous Detector Waveforms

cover one of the two quadrature signals. Each detector will recover the quadrature chrominance signal that is either in the phase or 180 degrees out of phase with the reinserted 3.58 MC subcarrier applied to that detector, and will ignore the other quadrature signal.

The action of the synchronous detector may be explained with the aid of the simplified waveform drawings of FIGURE 3-29. The 3.58 MC subcarrier is supplied to the suppressor grid and has an amplitude of about twenty to thirty volts. It may be considered, for the sake of simplicity, as gating the tube into conduction on the positive half cycles, and out of conduction on the negative half cycles. The gating action of the 3.58 MC subcarrier signal on the suppressor grid with no other signal applied may be seen in FIGURE 3-29a. The plate current consists of half cycle pulses, whose average value is indicated on the diagram. This average plate current may be called the no-signal average plate current. We can now examine the action when the combined chrominance signal is applied to the control grid. The result when the signal on the control grid is in phase with the suppressor signal is shown in FIGURE 3-29b; and the result when the two signals are ninety degrees out of phase is shown in FIGURE 3-29c.

A study of the in-phase condition shows that the control grid is now more positive whenever the tube is gated into conduction, and, as a result, the pulses of plate current are of greater amplitude. Thus the average plate current is increased, as shown, and an output corresponding to the amplitude of the control-grid signal is obtained. If the signal on the control grid is 180 degrees out of phase with the suppressor signal, then the control grid is more negative whenever the tube is gated into conduction, and the pulses of plate current are now of smaller amplitude,

The average plate current is now less than the average plate current for the no-signal condition. An output of opposite polarity is therefore obtained.

A study of the ninety degree out-of-phase condition, illustrated in FIGURE 3-29c, shows that during the half cycle when the tube is conducting, the signal on the control grid is both negative and positive, thus causing an approximately equal decrease and increase in plate current. The average change in plate current over the entire cycle is therefore zero. Thus it can be seen that when the signal on the control grid is ninety degrees out of phase with the suppressor signal, there is no change in plate current, and consequently no output in the plate circuit.

The output of the demodulators, then, varies from a maximum when the two signals are in phase, as shown in FIGURE 3-29b, to the no-signal average value when the two signals are in quadrature, as shown in FIGURE 3-29a, and to a minimum when they are 180 degrees out of phase. This is summarized in FIGURE 3-30, which shows the output voltage at all phase angles from zero to 360 degrees. Note that the output of the detector may be negative or positive depending upon the phase angle between the two signals.

The output of the demodulator contains color video signals and is the difference between the frequencies of the reinserted subcarrier and the input signal. A low-pass filter is used in the output to filter out the signals at 3.58 MC and allow

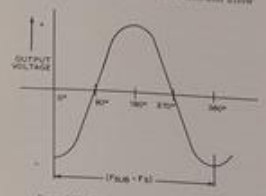


Figure 3-30 — Synchronous Detector Output Voltages

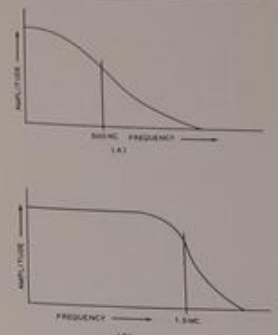


Figure 3-31 — I and Q Filter Responses

the color video signals to pass. As mentioned previously, the highest video frequency for which any color information is transmitted is 1.5 MC; only the *I* signal has the wide bandwidth, while the *Q* signal is limited to 0.5 MC. The *Q* filter response curve is, therefore, as shown in FIGURE 3-31a, and the *I* filter response curve is as shown in FIGURE 3-31b.

The output of the *Q* filter is next fed to a phase splitter, which provides the required positive and negative signals for the matrix. The cathode of the phase splitter is of low impedance. In order to match the frequency response of the cathode circuit to that of the higher impedance plate circuit, a capacitor is added across the cathode resistor. The value of the cathode capacitor has been chosen to have the same by-passing action in the cathode circuit as the interelectrode and wiring shunt capacitances in the plate circuit.

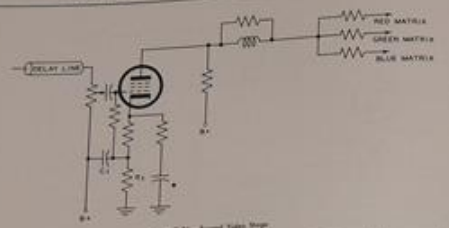


Figure 3-24 — Second Video Stage

The second video stage, shown in FIGURE 3-24, is a normal voltage-gain stage, which feeds the three Y matrix resistors. This stage is also degenerated, but with an impedance that produces some high-frequency peaking to increase the high-frequency response of the stage. This shunting effect of the capacitors in the cathode circuit reduces the degeneration at higher frequencies. In other words, the degeneration is maximum for low frequencies, producing, in effect, peaking at high frequencies. The frequency response of this stage is shown in FIGURE 3-25. As can be noted in FIGURE 3-22, the low side of the Y contrast control is connected to B+. This removes hum and B+ voltage fluctuations. The resistor R1 and capacitor C1 in the cathode of this stage impress the same fluctuations on the cathode and grid, and no change in the plate current will occur. Capacitor C1 is made large enough to pass hum and B+ fluctuations.

Band-Pass Amplifier — A simplified circuit of the band-pass amplifier is shown in FIGURE 3-26. The function of this stage is to select the video information between 2.5 and 4.2 MC and supply the necessary amplification to feed a low-impedance Color Saturation, or *Chroma*, control. As explained before, the control must be of low impedance to minimize the effect of the shunting capacitance of the control. In order to accomplish the selection, a band-pass network is used. This could be compared to a wide band IF stage whose center frequency is approximately 3.2 MC. Due to the extremely large bandwidth compared to the center frequency, a type of circuit

Figure 3-25 — Second Video Frequency Response

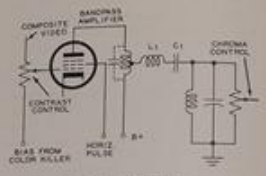


Figure 3-26 — Band-Pass Amplifier

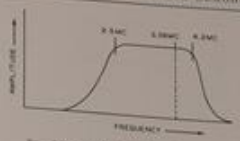


Figure 3-27 — Band-Pass Circuit Frequency Response

different from the usual IF amplifier was chosen. At center frequency, the coupling element L1-C1 is a short circuit; it is necessary to tap down on the plate circuit coil to obtain a high impedance in the plate circuit for high gain and a low impedance secondary for feeding the color-contrast control. The frequency response of the band-pass circuit is shown in FIGURE 3-27.

In order to make the color portion of the receiver inoperative during the reception of black-and-white signals, a negative voltage from the color killer is applied to the grid of the band-pass amplifier, thereby cutting it off. The operation of the killer circuit is as follows: the grid of the killer tube, V112B, is tied to the negative side of the phase detector. During color transmission, the transmitted burst is rectified and the negative DC voltage developed is used to keep the killer tubes cut off. Without incoming burst, the killer tube will be allowed to conduct, and a bias voltage will be developed at the plate by rectification of the positive horizontal pulse, in a manner similar to keyed AGC circuits. This bias voltage is applied to the grid of the band-pass amplifier through the contrast control. As a result, the band-pass amplifier will be cut-off during black-and-white transmissions. It is desirable to incorporate a killer tube in a receiver in order to prevent the chrominance channel from detecting high-frequency black-and-white information and producing colored crosstalk.

Also, in order for the DC restorer to work satisfactorily, it is necessary to key out the color burst signal. This is accomplished by keying off the band-pass stage during burst time with negative pulses obtained from the horizontal circuit. A negative voltage pulse is obtained from the horizontal output transformer 3T117 terminals E and G. The pulse is delayed slightly by resistor 2R312 and capacitor 2C260. The delay is necessary because burst occurs some time after the horizontal sync pulse. The negative pulse is applied to the screen of the band-pass amplifier, cutting it off during burst time.

3-2. *Color-Demodulation Section*

The signal that is passed by the band-pass amplifier is the vector sum of the two chrominance signals in quadrature. These two signals must now be separately recovered. This is accomplished by two phase-sensitive detectors known as synchronous detectors, or demodulators. Each of the detectors is arranged to recover one of the two color signals. A simplified circuit of a synchronous detector is shown in FIGURE 3-28.

The combined chrominance signal and the 3.58 MC subcarrier signal are applied to each detector. The 3.58 MC subcarrier signal is recreated in the receiver color-sync section and is applied to one of the detectors directly, and to the other detector through a ninety-degree phase-shifting network. The output from each detector depends upon the *relative* phase between the reinserted 3.58 MC subcarrier and the chrominance signal. Since the reinserted subcarriers are ninety degrees apart, each detector will re-

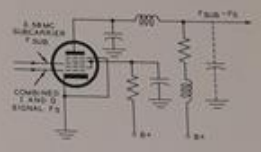


Figure 3-28 — Synchronous Detector

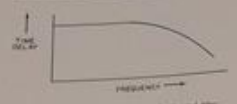


Figure 3-18 — Time Delay of a Mutually Coupled Filter

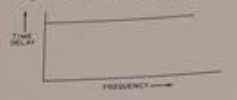


Figure 3-19 — Combination of 3-17 and 3-18

type used in the luminance channel in this receiver can be considered as an extremely large number of central sections in series.

First Video Stage — The functions of the first video stage of the color receiver, shown in FIGURE 3-22, are as follows:

1. Provide about 100 volts of video signal independent of contrast control to feed the sync separator.
2. Provide about 10 volts of burst signal to feed the burst separator.
3. Provide a contrast control for the luminance, or Y, channel that does not interact with other signals, and provide an output level of 15 volts. This signal must be limited in bandwidth to attenuate the 3.58 MC subcarrier.
4. Provide a signal for the color band-pass stage of 1.5 volts, incorporating a contrast control

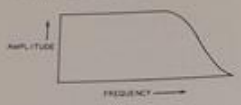


Figure 3-20 — Frequency Response — Combined Simple and Mutually Coupled Filters

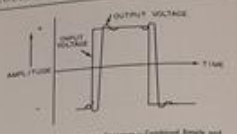


Figure 3-21 — Square Wave Response — Combined Simple and Mutually Coupled Filters

that maintains the relative phase of burst and the color signal.

5. Incorporate high attenuation for sound.

To minimize the phase shift and the input loading on the detector, a pentode tube was chosen for the first video stage. In order for this tube to handle the output signal of the detector and produce distortion-free output, cathode degeneration was added to this stage to improve linearity. An impedance in the cathode-circuit causes degeneration; because the voltage drop across the cathode impedance is opposite in polarity to the input signal and reduces the net grid-to-cathode voltage of the tube. The amount of degeneration is proportional to the size of the cathode impedance and to the tube gain.

The reduction in gain of a stage by placing an impedance in the cathode is utilized to form a sound trap by inserting a parallel-tuned circuit 2L108 and 2C184, adjusted to resonate at 4.5 MC. Amplification at 4.5 MC is therefore reduced.

The output is taken from the cathode circuit, and the contrast control for the chrominance signal is placed across the cathode resistor. This circuit is of low impedance in order to minimize the high-frequency attenuation and the phase shift caused by the shunting capacitance of the control and the following stage. The reason for this is as follows: a shunt capacitance across the contrast control will form a parallel path of lower impedance for the higher video frequencies, and cause a falling off of high-frequency response. Also, if this shunt capacitance varies as the arm

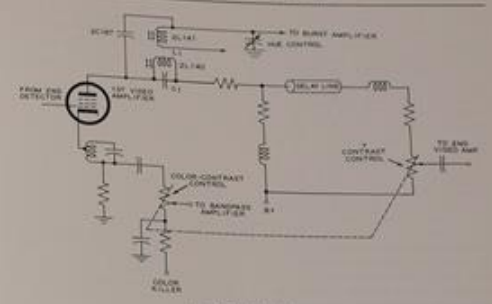


Figure 3-22 — First Video Stage

of the control is moved, a different amount of phase shift will be introduced at different settings of the contrast control. This will cause errors in the color reproduction. However, if the contrast control impedance is low, the effect of the shunting capacitance will be minimized.

The plate circuit of the first video amplifier shown in the simplified diagram in FIGURE 3-22 uses a filter with a resonant element C1 and L1 to limit the output at 3.58 MC. This trap, labelled 2L140 and 2C160 on the main schematic, is tuned to the color subcarrier frequency. It thus produces the amplitude response shown in FIGURE 3-23. The burst signal is taken directly from the plate. Since the available delay line has a termination impedance of 2700 ohms, it is tapped across the load resistor to match the delay-line impedance. The effect of C1 and L1 stray capacitance across the input of the delay line is minimized by the use of a shunt peaking inductance. The output of the delay is terminated into 2700 ohms through a series-peaking element. In order to minimize the effects of the input capacitance of the second video amplifier, the Y contrast is tapped down, as previously explained, to prevent phase shift and loss of the higher video frequencies.

The color contrast control and Y contrast control are ganged to vary the gain of the color and the Y channel together, so that the customer can adjust the contrast of the picture without having to reset color saturation.

Figure 3-23 — First Video Frequency Response

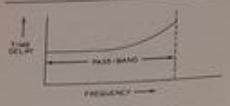


Figure 3-11 — Low-pass Filter Time Delay

narrower the bandwidth of a filter, or the lower the cut-off frequency, the greater the time delay it will introduce.

The reason for the time delay introduced by the filter may be explained by referring to FIGURE 3-12. If a sudden rise in voltage e_{in} is applied to a capacitor through a resistor, the voltage across the capacitor e_{out} will not rise suddenly but will follow the dotted curve.

If a sudden voltage is applied to an inductor and resistor, as shown in FIGURE 3-13, the voltage across the resistor will not rise suddenly but will take time to rise, as shown by the dotted curve.

Since the low-pass filter contains a series inductance and a shunt capacitance, time is required to build up the voltage across the output resistor. The filter may also distort the wave-shape of signals passing through it. If a square wave, as shown in FIGURE 3-14, is impressed on this type filter, the voltage e_o at the output will approximate that shown by the dotted curve, due to the time delay introduced by the filter. A rise time up to 50 per cent may be approximated as the time of one-quarter cycle of the cut-off frequency. Thus, the lower the cut-off frequency, the slower the rise time, and, therefore, the longer the time delay introduced. The time delay is also proportional to the number of sections used.

As explained in earlier lessons, the required bandwidth of the Y, I, and Q channels are all different, and different delays must be introduced. Also, an additional delay is experienced by both I and Q in the bandpass amplifier. (The delay introduced by the band-pass filter is approximately the same as that of a low-pass filter having one-half the bandwidth.) In order to obtain the best edge effects, it is necessary to match delay times at the 50 percent point. It is at the edges of the areas in the picture that

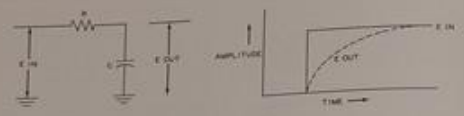


Figure 3-12 — Time Delay in an RC Filter

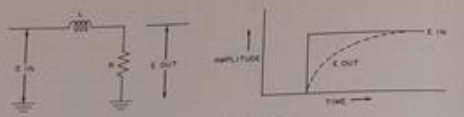


Figure 3-13 — Time Delay in an LC Filter

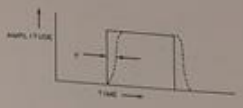


Figure 3-14 — Waveshape Distortion by a Filter

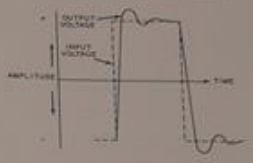


Figure 3-15 — Square Wave Overshoot Due to Filtering

square wave video signals, both luminance and chrominance, are produced. The rise time and the time delay of the wideband Y channel could be represented by a curve A of FIGURE 3-15; that of the medium-band I channel by curve B, and that of the narrow-band Q channel by curve C. To effect optimum results, Y must be delayed by the time difference between t_3 and t_1 and I by the difference between t_2 and t_1.

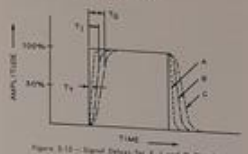


Figure 3-16 — Signal Delays for Y, I and Q Signals

As can be noticed from FIGURE 3-11, the time delay curve is relatively straight for approximately *half the pass band*. If a large number of sections, each of wider bandwidth than required, is used, relatively constant time delay can be obtained over the entire desired pass band. However, using a great number of wideband sections introduces attenuation as well as a loss of selectivity. Also, since the time delay of the simple filter increases with frequency, the various frequency components of the square wave are phase shifted, and the resulting square wave response is as shown in FIGURE 3-16. Note the overshoots, or ringing, at the beginning and the end of the pulse. By arranging a network as shown in FIGURE 3-17, its time delay can be made to have the effect opposite to that of the filter shown in FIGURE 3-9. This type of filter is called a mutually coupled filter. The time delay of such a network is shown

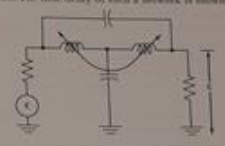


Figure 3-17 — Mutually Coupled Filter

in FIGURE 3-18. Note that this is the inverse of the delay curve in FIGURE 3-11, and a combination of both can produce a uniform time delay as shown in FIGURE 3-19 and a frequency response as shown in FIGURE 3-20. The square wave response of this network is shown in FIGURE 3-21. Compared to the response shown in FIGURE 3-16, there is less ringing and a more symmetrical response, a result of using this network instead of the simple filter.

An example of such a network may be seen in the I filter, which is labelled 2T123 on the receiver schematic diagram. A delay line of the

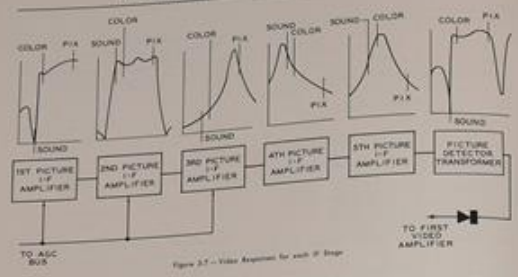


Figure 3-7 — Video Response for each IF Stage

An examination of the first IF stage response curve will show that sound is attenuated in the first IF stage. The first picture IF grid transformer attenuates the sound IF carrier sufficiently to give the desired ratio of 15:1 for sound to picture carriers at this point. This attenuation re-reduces the cross-modulation between the sound carrier and the color subcarrier thereby eliminating a possibility of a 920 KC beat in the picture. The degree of attenuation is controlled by the sound-level control 1R166 in the first picture IF grid circuit. This adjustment is made during the receiver alignment.

Following the first IF amplifier is a bandpass circuit similar to the type found in some black-and-white receivers. There are two rejection traps in this band-pass circuit. One of the rejection traps is tuned to the adjacent sound frequency (47.25 MC), and the other is tuned approximately midway between the adjacent picture and accompanying sound carriers (40.7 MC). The purpose of the trap at 40.7 MC is to keep down the response to possible adjacent picture interference and obtain the desired skirt selectivity in the region of the accompanying sound IF carrier.

The second, third and fourth picture IF stages are stagger-tuned stages. These circuits are often found in black-and-white receivers. Bifilar coils, used for coupling between stages, eliminate coupling capacitors and hence reduce the effect of noise pulses by reducing the capacitive "set-up" on noise pulses. A coupling capacitor charges up on noise pulses and then discharges after the noise pulse is over. Both the charging and discharging pulses of current are visible on the screen, making the noise pulse duration appear more than it actually is, and increasing the visible disturbance. The use of such staggered stages provides some flexibility for achieving the curve shape of FIGURE 3-6; the exact resonance of these circuits may be shifted to make up for variations that may occur elsewhere in the IF section.

At the plate of the fifth picture IF tube, the amplitudes of the sound and picture carriers are in the correct ratio for intercarrier sound detection. The sound carrier is down about 15 times. However, considerably more sound rejection is necessary before video detection to avoid a 920 KC beat in the picture. Before this additional attenuation is inserted, sound at the IF frequency

is taken off at the plate of the fifth IF stage and applied to a separate sound detector. Then additional selectivity is inserted in the picture channel to attenuate sound to approximately a total of 2000 times down. The additional sound rejection is provided between the plate of the fifth IF tube and the video detector by the picture-detector transformer, which contains an inductively-coupled absorption trap at the sound IF frequency. This technique is a departure from black-and-white IF circuits, where one detector is adequate. The sound IF and audio portions of a color receiver are similar to those of black-and-white receivers, except for the method of sound take off, and do not require detailed explanation.

Video Detector—This stage recovers the video information from the envelope of the IF carrier. Its load impedance should be low for IF and as high as possible consistent with producing a uniform impedance for all video frequencies. The coupling network must also attenuate IF frequencies and their harmonics to prevent IF energy from feeding back to other stages and causing regeneration. The desired effects can be obtained by using a low-pass filter, as shown in the simplified detector circuit of FIGURE 3-8, with its cut-off set above the highest video frequency desired.

The detector stage employs a 1N60 crystal diode and is operated at a high (6-volt peak) level in order to minimize nonlinearity effects of

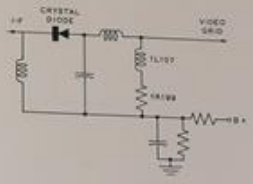


Figure 3-8 — Video Detector Circuit

the second detector curve at low level. It is floated above ground (about 1.5 volts) in order to obtain the desired bias for the succeeding video stage. The second detector load resistor is 1R199.

Impulse noise may produce pulses many times larger than the desired television signals. By arranging the polarity of the sound detector as shown, so that noise produces large negative signals that will cut-off the first video amplifier during impulse noise time, these noise pulses will be effectively clipped.

Video—In order to understand the reasons for some of the circuit arrangements in the video amplifier, it is necessary to understand the time delay introduced by filters of various bandwidths.

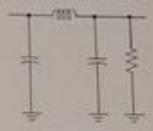


Figure 3-9 — A Typical low-pass filter

A typical low-pass filter is shown in FIGURE 3-9. This filter has an amplitude response as shown in FIGURE 3-10, and a time delay curve as shown in FIGURE 3-11. Note that the filter introduces a definite amount of time delay in the signal. The time delay is roughly proportional to *LC*. In a filter designed for a narrow bandwidth, *L* and *C* must be large. In such a filter, the time delay will be greater than in a filter with a wider bandwidth, since *LC* will be greater. Thus, the

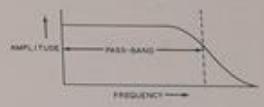


Figure 3-10 — Low-pass Filter Response

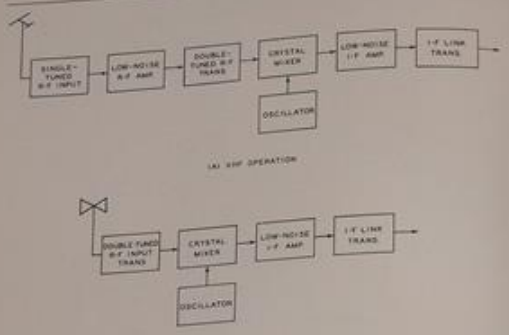


Figure 3-4.—RF Unit Operation

color signal of approximately 450 KC color modulating signal shown in FIGURE 3-2b, we see that the amplitude of the lower-sideband signal is roughly 30 percent higher than that of the upper-sideband signal. Distortion of this type results in a shift of color rendition; red, for example, might be reproduced with some green or blue tinting. To avoid reproduction errors of this type, good alignment must be maintained.

FIGURE 3-3 is a complete schematic diagram of the RF unit. Provision is made for 12-channel VHF coverage and 4-channel UHF coverage. The operation of this turret-type tuner for VHF and UHF is shown in block diagram form in FIGURE 3-4. As can be seen from the schematic diagram, the basic differences in operation between VHF and UHF are that the input transformer is changed from a single-tuned transformer at VHF to a double-tuned type at UHF, and the low-noise RF amplifier stage V1 is omitted at UHF.

Bias for the RF amplifier is supplied by the AGC system. Following the crystal mixer CR1 for both UHF and VHF is a low-noise IF amplifier stage made up of a grounded-grid amplifier. A driven-pentode output stage is cascaded with this amplifier. The plate circuit of the pentode contains the primary of a link-coupled transformer, which feeds the main IF section. The tuner output is in the 40 MC range.

The oscillator V2 is a modified Colpitts type using a 6AF4 tube, operating at the fundamental frequency for the VHF and UHF ranges.

IF Section—The circuit of the picture IF section of a color receiver requires detailed considera-

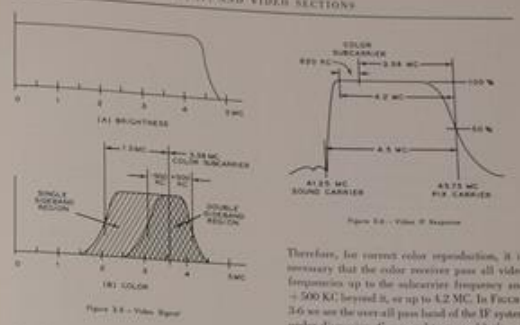


Figure 3-5.—Video Signal

Figure 3-6.—Video IF Response

tion. Some of the circuit requirements are new ones necessary for color. Although some of the circuits of the IF section, shown on the complete receiver schematic diagram, are new, the exact circuit arrangement is selected to accomplish specific aims that will be described.

In order to produce a color picture along with its accompanying sound, three fundamental items of information must be passed by the IF system. These are the picture carrier at 45.75 MC, its associated color subcarrier at 42.17 MC, and the sound carrier at 41.25 MC. The video information prior to RF modulation is as shown in FIGURE 3-5. There are two basic components of a color TV signal, as previously mentioned, namely the brightness or luminance information shown in FIGURE 3-5a, and color or chrominance information shown in FIGURE 3-5b. The color information is transmitted by a double sideband for a region of ± 500 KC about the subcarrier frequency, and then by a single sideband for those frequencies beyond —500 KC and extending to —1.5 MC from the subcarrier frequency. Therefore, for correct color reproduction, it is necessary that the color receiver pass all video frequencies up to the subcarrier frequency and +500 KC beyond it, or up to 4.2 MC. In FIGURE 3-6 we see the over-all pass band of the IF system under discussion. Compared to many black-and-white receivers, which have an average bandwidth of approximately 3 MC, the color receiver has a much wider bandwidth.

FIGURE 3-6 represents a practical limit for video bandwidth attainable if the sound carrier, at the intermediate frequency, is to be adequately rejected. When compared to the requirements for color as shown in FIGURE 3-5b, we see that only +500 KC beyond the subcarrier frequency is required, and approximately +620 KC has been provided for. The difference of 120 KC represents a guard band for the purpose of providing some freedom for fine-tuning inaccuracies before the upper sideband becomes lost or altered.

FIGURE 3-7 is a block diagram of the picture IF channel, starting from the secondary of the link-coupled transformer and extending to the video detector. Above each block is the approximate response curve for that stage. The summation of these individual response curves is represented by the over-all response curves shown in FIGURE 3-6. Automatic gain control is accomplished by providing bias for the first, second, and third IF amplifiers from the AGC system.

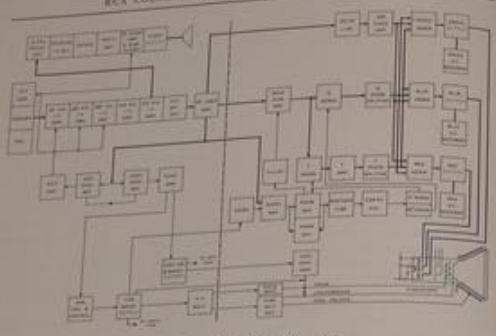


Figure 3-1—Block Diagram of an RCA Color Television Receiver

wide-band performance and uniform flat response on all channels essential for good performance in color television. FIGURE 3-2 shows four possible response curves for the RF bandpass. The desired condition is shown in FIGURE 3-2a. The others shown would probably be passable for black-and-white reception; but for color the subcarrier and its sidebands are altered to such an extent as to cause color distortions. An RF tuner having the response of FIGURE 3-2b will cause low saturation and poor color transitions (change from one color to another). High color saturations with poor color transitions will result for the condition shown at (*c*), and poor color transitions for a condition shown at (*d*). A color transition usually occurs at the edges of an object, giving rise to relatively high video frequencies. The change in color is therefore dependent on the higher color video frequencies.

Poor color transitions in the case of misaligned RF circuits result from a tilting of the pass band in the region of the color subcarrier. For example, if we consider the relative amplitudes of the upper and lower sidebands of the

Figure 3-2—Conditions of RF Bandpass Response

MODEL 5

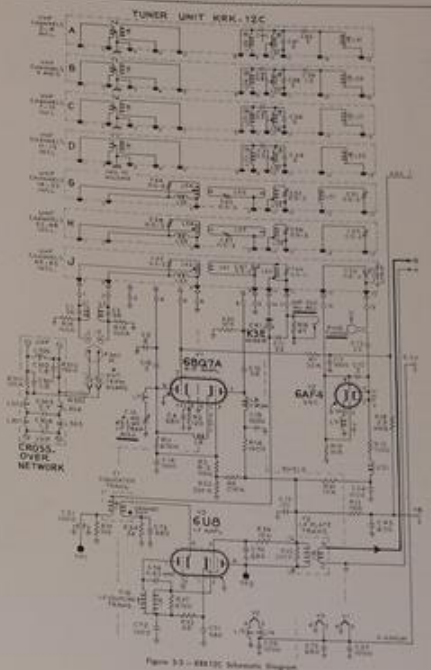


Figure 3-3—KRK12C Schematic Diagram

be included as part of the gamut. We would also want a wide range of saturation for all hues, so the triangle should be as large in area as possible. The largest triangle obtainable within the chromaticity diagram results from points at 400, 520 and 700 millimicrons, lying right on the curved boundary line. This will include quite a large area, and is the greatest range of color obtainable from primaries that we can see.* However, 100% saturated colors are difficult to come by in paints or light filters, and therefore we must settle with a compromise. Available practical colors are somewhat less than 100% saturations, and therefore the primaries we settle for are less than ideal. The triangle described by points R, G and B in FIGURE 1-12 is practical and attainable, but leaves out large areas in the greens, blue-greens and magentas. Actually, these colors rarely occur in nature, and even then only the practiced eye is able to distinguish between them.

Not many people are aware of the range of colors that the eye is capable of seeing. As further evidence of this, the colored area in FIGURE 1-12 is the gamut of printers' inks used in color printing processes today. No one will say that the color illustrations in today's books and periodicals are anything less than miraculous in their faithful reproduction. Yet notice how limited the ink gamut is on the chromaticity diagram.

The gamut specified by the FCC for color television is quite extensive. Not only does it include the gamut of printers' inks, but also includes the gamut of colors for photographic color reproduction. The color television gamut is illustrated by the triangle R-G-B in FIGURE 1-12. By inclusion of the printers' ink and color photography gamuts, color television can reproduce printed pictures and color movies as faithfully as the eye is capable of seeing them at first hand.

*Notice that this triangle does not include all colors that the average eye can see. In order to include the total area of the chromaticity diagram within three points, the points must lie outside the visible range of color. For this reason, the three primaries making up the chromaticity diagram are considered purely mathematical and invisible.

1-9. Psychological Aspects of Color

To this point we have learned some of the basic principles of color; what hue, saturation and brightness are, and what is necessary to produce a black-and-white picture from three colored video signals. Little mention has been made as to what the color video signal consists of, and how certain vagaries of the eye are taken into consideration in its make-up. By now you know that the color signal carries the hue and saturation factors of color. These two factors combined are often referred to as chrominance information; the word chrominance meaning reference to color without regard to brightness. Thus, a chrominance signal is one that conveys hue and saturation, and is the color signal in color television transmission.

A chrominance signal is produced at the transmitter, and added to the black-and-white or brightness signal when a color program is telecast. This chrominance signal must in no way interfere with reception of the color program in black-and-white on a black-and-white receiver. With this restriction, plus the fact that color must be present in certain amounts of picture detail (the finer the detail the wider the video bandwidth) presents certain design problems. The chrominance signal has to be wide enough in bandwidth to present good color definition, and yet be placed with the brightness signal in such a way that the two do not interfere with each other. The design problem we will consider here is just what constitutes "good color definition."

At first glance it appears that color should be present in all picture detail, requiring a chrominance signal 4 MC in bandwidth. If this were the case, however, compatible color television would be an impossibility since two 4 MC signals in the same frequency allocation would cause objectionable interferences with each other. Such is not the case because it has been found that the eye is not capable of detecting color in fine picture detail, and it is therefore not necessary to transmit chrominance signals for as wide a bandwidth as the brightness signal. In the process of discovering this fact, it was also found that the eye does tricks with colors with variations in color areas. These "quirks" of the human eye come under the general heading of the "psychological aspects of color," which means that the eye has its faults when it comes to interpreting the hard, cold facts of the science of color.

You are probably aware of the fact that colors do not always appear the same under different viewing conditions. For example, blues and greens often become confused when viewed under artificial lighting conditions. A woman's dress might appear pale blue-green at a distance, but upon closer inspection found to be a bright green and white check. These illustrations are practical examples to the fact that all of us are color blind under certain conditions. Fortunately for color television this is so. Otherwise, high definition color television would not be with us today. By experimentation and research it has been found that this color blindness follows a definite pattern for people with normal eyesight. This change in color from true to apparent takes place when the areas of colors in a scene become small. The eye cannot resolve color in small areas. Because of this the eye becomes confused at what it sees, and the eye interprets the true colors erroneously. An example of this is illustrated in FIGURE 1-13. This is a reproduction of a close-up photograph of a color kinescope operating to produce a white raster.

Close inspection will reveal integrated fields of red, green and blue dots. These are small spots of phosphor, emitting light by activation from three electron beams. Upon moving the page slowly away from the face, at some point the green and blue dots will become indistinguishable from each other as to color. The result is an apparent field of red dots on a pale blue-green background. By holding the page at arm's length and squinting at the illustration, it appears to blend into a pale pink square. The point brought forth by FIGURE 1-13 is this: certain colors tend to blend at certain distances from the eye when

Figure 1-13.—Illustration of Normal Color Blindness

their areas are equal and small, while other colors maintain their true color under the same conditions; a color also tends to appear differently as the color area becomes smaller. This shift in color with decrease in color area follows a pattern, and this pattern is illustrated on the chromaticity diagram in FIGURE 1-14.

As color area in a scene becomes smaller, all colors are seen as either cyan or orange. The eye is not capable of telling the difference between,

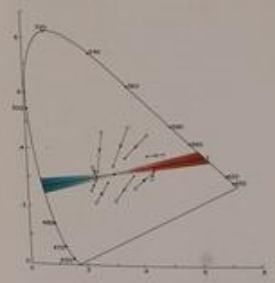


Figure 1-14.—Resolving of Color Detail in the Orange-Cyan Line

MODEL 5

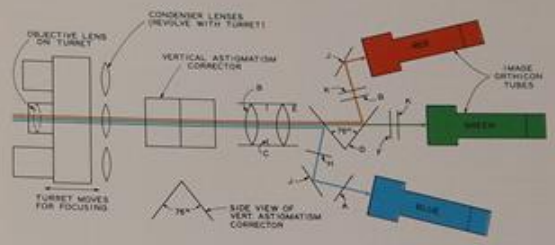
Lesson 2

2-1. *Requirements of the Color Television Signal*

One of the primary requirements of a color television system is to provide high definition black-and-white pictures for present standard black-and-white receivers without any modifications to the receivers. This means that, first, a color telecast must provide a full 6 MC black-and-white signal with the same amplitude modulation, sync and blanking characteristics as does any ordinary standard black-and-white telecast. Secondly, the chrominance information, which includes the hue and saturation variables of color, must be transmitted within the standard 6 MC television channel and thirdly, the transmitted chrominance information must not in any way cause objectionable interference with the black-and-white signal (the brightness variable of color).

At first glance, this seems to be a difficult task to accomplish, since the 6 MC channel is apparently already well filled. However, as will be learned in the discussion to follow, it is possible to transmit the chrominance information, along with the black-and-white signal, within the standard 6 MC television channel.

In developing the color television signal, a method which is not presently used for color transmission will first be discussed. This will lead into development of the present system of high color definition transmissions. It is felt that treating the subject in this manner will give the reader a better understanding of the techniques involved.



A. HOR. ASTIGMATISM CORRECTOR
B. RELAY LENSES BOTH 9.5" F/4
C. REMOTELY-CONTROLLED IRIS
D. RED REFLECTING DICHROIC
E. BLUE REFLECTING DICHROIC
F. GREEN TRIMMING FILTER
G. RED TRIMMING FILTER
H. BLUE TRIMMING FILTER
J. FRONT SURFACE MIRRORS
K. NEUTRAL-DENSITY FILTERS

Figure 2-1 – The Optical System Used in an RCA Three Tube Color Television Camera

At the receiver the *R-Y* signal is applied to the red adder, and no signal is applied to the blue adder, *B-Y* not being transmitted. In developing *G-Y* at the receiver, then, the *B-Y* component of *G-Y* is missing and the *G-Y* signal consists only of —.51 *R-Y*.

These are not the complete color difference signals necessary to reproduce faithfully the original picture elements of the televised scene, but the kinescope will interpret the signals that are present as colors. Observing the picture tube inputs for the red televised element, notice that the red kinescope input is 100% amplitude (30% *Y* plus 70% *R-Y*) as it should be. Normally the green and blue kinescope guns would be inactive on this red picture element, since the *B-Y* signal produces a signal amplitude for a red signal that will cancel all input to the blue and green guns; but due to the absence of *B-Y* the blue and green guns will conduct. The result is that the kinescope will interpret the televised fully saturated red as magenta, slightly less saturated than 100%.

Following these waveforms through from color camera to kinescope for green, blue and yellow will prove out the fact that, without *B-Y* the reproduced colors for red, green, blue and yellow will be magenta, bluish-green, green and very pale magenta, respectively.

If this absence of *B-Y* is carried out for all colors, the kinescope will interpret all colors as either bluish-green or bluish-red. On the other hand, if the *R-Y* cable were opened up and only *B-Y* and *Y* transmitted, all colors would appear on the kinescope as either a reddish-blue or greenish-yellow.

Either one of these two-cable color systems will contribute only part of the necessary chrominance information for accurate color reproduction: both *R-Y* and *B-Y* are necessary for faithful color fidelity.

For purposes of illustration, the color difference signals are plotted on the CIE chromaticity diagram in FIGURE 2-12.

If only *R-Y* were transmitted, only colors along the bluish-green, through white, to bluish-red line would be reproduced on the kinescope. With *B-Y* transmitted alone, only yellowish-green or reddish-blue would be reproduced on the kinescope. It can be seen by this illustration that if colors are to be reproduced that do not fall on either of these lines, *both* color difference signals must be transmitted. Since the color television system is required to reproduce all colors, then two chrominance signals plus the *Y* signal are necessary to the system's operation.

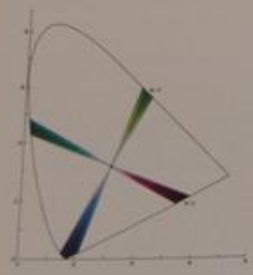


Figure 2-12 — R-Y and B-Y Chromaticity Coordinates

2-9. *Chrominance Transmission within the 6 MC Television Channel*

FIGURE 2-13 illustrates the television signal displacement within the standard six megacycle allotment of spectrum space for one television channel. Most of this space is taken up by the black-and-white video signal with only a small guard band at the low frequency end, and the sound carrier (with sidebands) and another guard band at the high frequency end. The black-and-white signal fills 3.35 MC of the channel allocation. At first glance it would seem impossible to transmit chrominance information within this space without causing serious conflict with the signals already present. However, this is not the case.

The reason that channel space is available for signals other than the *Y* or brightness signal is that when a black-and-white picture is scanned, the signals resulting are found to cluster around the harmonics of the frame scanning frequency (30 cps) and the line scanning frequency (15,750 cps). Nearly half the space between the frame and line scanning frequency harmonics up to video band pass cutoff (4.1 MC) is relatively devoid of video information. By selecting a chrominance signal carrier frequency that is an odd multiple of one-half the scanning frequencies, the chrominance signal can be made to fit into the voids between clusters of *Y* video signal. The chrominance signals will also cluster about the harmonics of its base frequency (½ the scanning rate), and the two signals will fit together without conflict.

It has been found by experimentation that if the chrominance signal carrier is placed in the upper sideband 3.58 MC from the picture carrier, the maximum bandwidth of chrominance signals can be utilized without causing interference with the accompanying brightness signal. This 3.58 MC chrominance carrier is called a subcarrier, since it is inserted into the standard video sideband before the video signal is applied to the picture RF carrier. The sideband information of the subcarrier is not related to the sideband information of main picture carrier, although it occupies the same spectrum space; hence the term subcarrier.

In practice, the 3.58 MC carrier is suppressed, since in the case of color television, this subcarrier only wastes transmitter energy. The subcarrier is necessary for the purpose of detection in the receiver, but can be readily reinserted at the receiver with appropriate synchronizing signals.

Previously it was proved that two chrominance signals are necessary to reproduce all colors.

Figure 2-13 — Frequency Allocation of a Television Channel

Naturally, both of these signals must have bandwidth. The more color definition the wider the bandwidth of chrominance signals. There is a limited amount of space in the *Y* video sideband to place these signals. For this reason a special method of combining the chrominance signals "in quadrature" is employed. The two chrominance signals are amplitude modulated at the same 3.58 MC subcarrier frequency, *but the two signals are phase displaced by ninety degrees.*

The two amplitude modulated signals are combined, forming a single modulation envelope that is the resultant of the combination of the two differently phased signals. If detected by a phase sensitive device, the original signals can be separated from the resultant signal. There is nothing mysterious about this, since conventionally two signals are maintained separately by transmitting them at different frequencies. A frequency sensitive device (such as an RF unit of a television receiver) will detect these as individual signals. Using the converse of this conventional method, two signals of the *same frequency* but of *different phase* can be detected by a phase sensitive device.

FIGURE 2-14 is a block diagram of a system utilizing the principle of transmitting the chrominance signals in quadrature. The output of the three camera tubes (through the matrix) are made to produce *R-Y*, *B-Y* and *Y* signals. The two color difference signals are amplitude modulated on a common 3.58 MC carrier, but the

uration color, while a brilliant color is high in brightness but saturation is also high. Thus the difference between a pale and a brilliant color is only the saturation content of the color. The adverb modifier *very* denotes an extreme condition of one of the adjective modifiers.

The terminology of the headings in the color description chart are pure grade school grammar, and their meaning is of little consequence to us at this time. It suffices to say that if a color were described to you as a "very pale reddish orange" you would know by studying the chart that it would be very high brightness, very low saturation of an orange hue with a tinge of red.

It would be well to study the chart until you are familiar enough with the terms to describe any color that comes to mind. These terms are truly descriptive of colors, and anyone from a layman to a scientist would understand your speaking of colors in these terms.

1-8. Color Standardization

To those associated with the science of color it is a well known fact that no two people see color exactly the same. Human eyes are as different between people as fingerprints. Fortunately this difference in color interpretation between individuals is only discernible under laboratory conditions. Otherwise the world would be in chaos trying to figure out whether the sky was blue or green or "popcorn pink"! This slight difference in color interpretation *is* of great concern, however, to people who must deal with the science of color. The findings of one scientist might be based on his own interpretation of color, and would do another scientist no good unless he had exactly the same optical characteristics. For this reason the International Commission of Illumination (ICI—sometimes referred to by its French initials, CIE) met in the late 1920's and adopted a standard set of primary values, illustrated in FIGURE 1-11. These curves are meaningless to the eye as light values or filter responses, but represent the amounts of three mathematically developed primaries that will produce 100%

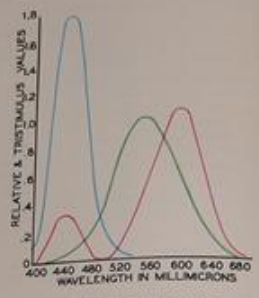


Figure 1-11 — Standardized Color Mixture Curves

saturations of all visible light wavelengths. With these curves a formula can be developed for any color that will tell the full story of that color in *concise, standardized* terms.

Our purpose in bringing up the subject of fundamental color mixture curves is to point out that from these curves a "color map" or *chromaticity diagram* can be developed. This color map will provide us with a plotting ground for explaining some of the color phenomena relating to color television. The word *chromaticity* defines the hue and saturation of light (as it would be received by the average eye of a group of people) as viewed under specified conditions. The chromaticity diagram therefore will include all of the hues and their saturations that the average human eye can see. Notice that there is no reference to brightness in describing the chromaticity diagram. Since brightness is a psychological condition of color, it has been omitted for the purpose of studying color (chromaticity) alone.

The chromaticity diagram is produced by plotting the amounts of the three curves that occur at

regular intervals of wavelength throughout the visible range of light. This produces a horseshoe shaped curve illustrated in FIGURE 1-12. Points along this curve represent 100% saturations of colors in the light spectrum, and the points are assigned wavelength designations in millimicrons.

The colored area in FIGURE 1-12 gives an indication of how colors lie in the diagram. The spectrum is laid out around the curve from blue, through green (at the top) to red. Since all colors are represented in the diagram, white is also included. The point at the center of the white area is called "equal energy white" and is the purest white attainable.

The two ends of the curve have been joined by a straight line to represent non-spectral magentas. These colors do not occur in the light spectrum and consequently cannot be defined in terms of wavelength; however, since they do occur in nature, magentas must be represented in the chromaticity diagram.

The various hues of magenta are sometimes defined in terms of their *complementary* wavelengths. Complementary colors are any two colors that when combined produce white (this does not violate the rules of primary colors, since three primaries are represented in any two complementary colors: green and magenta are complements producing white; magenta is a combination of red and blue, so red, green and blue are represented). FIGURE 1-12 indicates one magenta having a wavelength of 500c millimicrons, which is nothing more than a notation that that particular magenta is a complementary of green, having a wavelength of 500 millimicrons.

Any point within the chromaticity diagram represents a hue and some saturation of that hue. If two points are plotted, the connecting line between them will indicate all of the colors that can be produced by combination of the two hues at the points. This connecting line is called the *gamut*, or range, of two colors. If three points are plotted that do not fall on a straight line (in

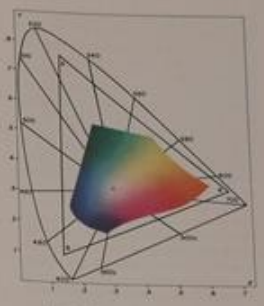


Figure 1-12 — The CIE Chromaticity Diagram

other words, that form a triangle) various combinations of the three colors at the points will produce a gamut of all colors that fall within the included area. Any three such points are considered as primary colors, since it is impossible for any two points to produce the color of the third point. It was pointed out earlier in the lesson that three primaries do not necessarily have to produce all colors of the rainbow to be called primaries. Consider three points forming a triangle in the green region. This gamut includes only shades of green, yet the rule defining primaries is not violated because the three points are not on a straight line. The most *useful* set of additive primaries, however, are located so that the gamut area includes white. If three colors can produce white, by variation of amounts they can produce all other hues, since white is a product of all hues.

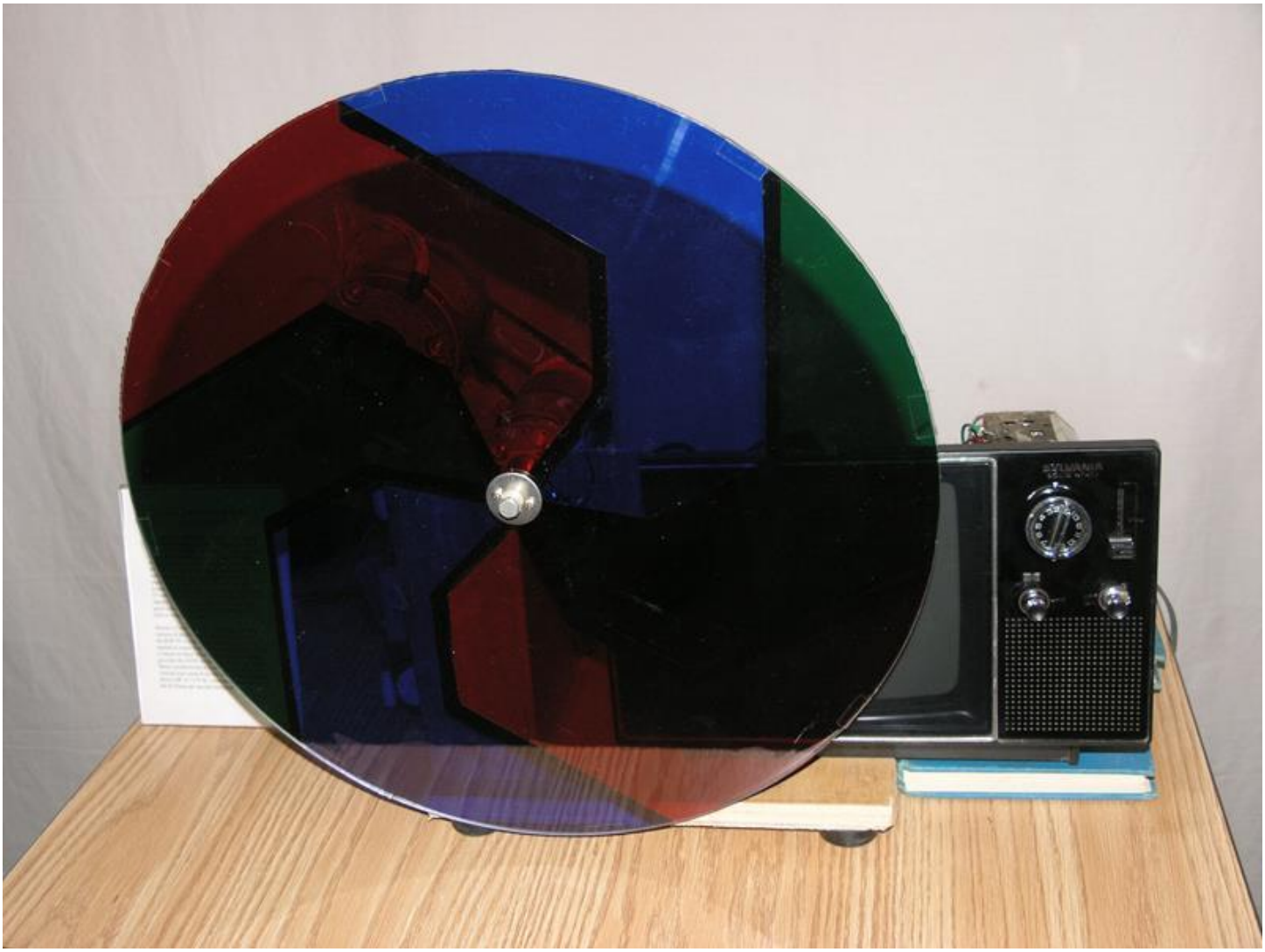
Suppose that we wish to plot a set of primaries for color reproducing purposes. Naturally we would want all hues represented, so white would


ABC


ASTRONAUT


Modern Version of Col-R-Tel
Color Wheel


Ulbon
Optical Precision
MODEL
CUST P/N
DATE CODE
SYNCHRONOUS MOTOR
FRM


SYLVANIA


GLASS
CATHODE RAY TUBE
HANDLE WITH CARE
FRAGILE
Crimmer
Moving & Storage, Inc.
EPSON P5000


GLASS
CATHODE RAY TUBE
HANDLE WITH CARE
FRAGILE
THIS SIDE UP
HANDLE WITH CARE
Storage, Inc
MASTER
EPSON P5000


Amptech
Systems


Tektronix


43573
KEEP FROZEN


RCA
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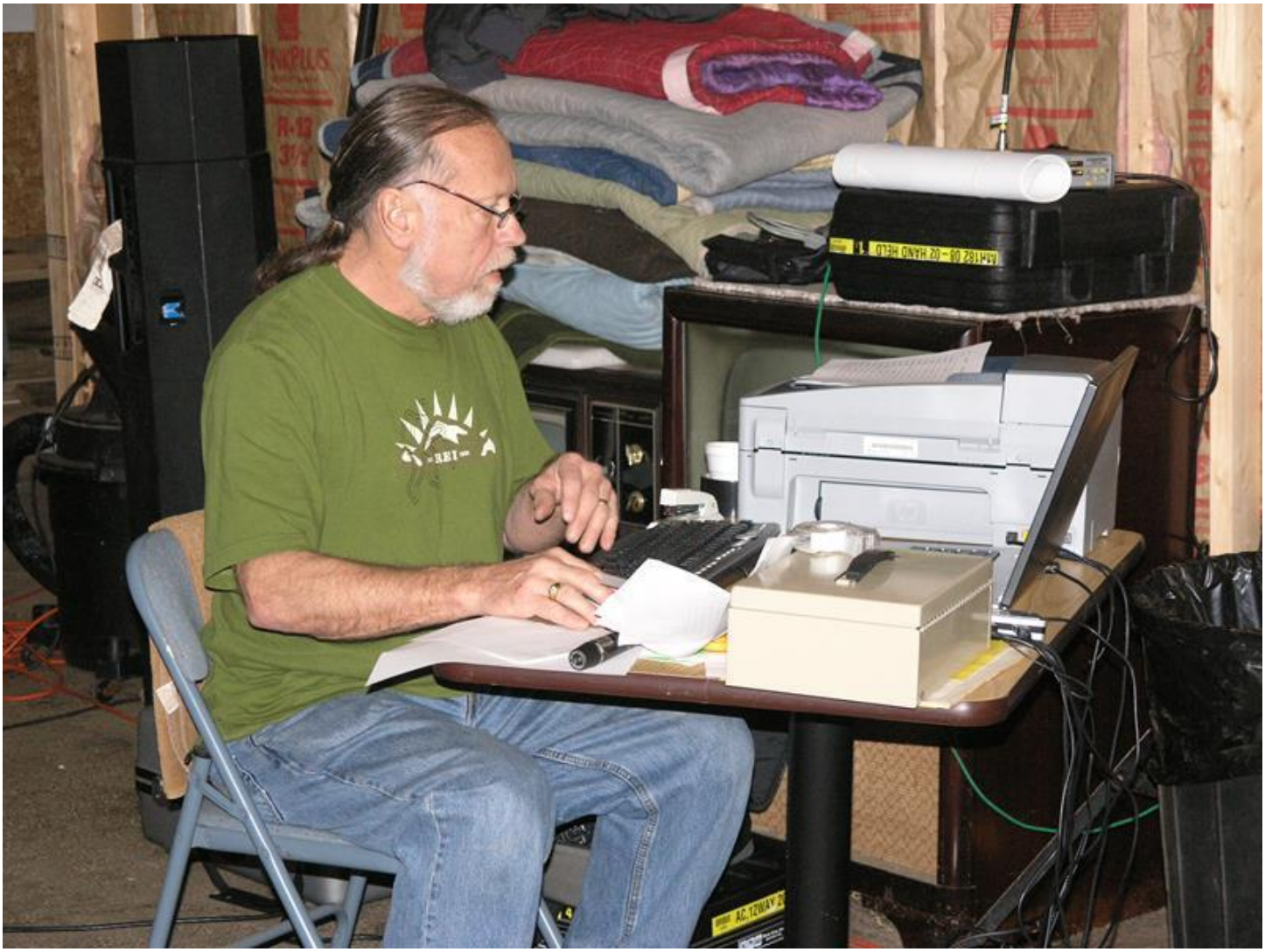
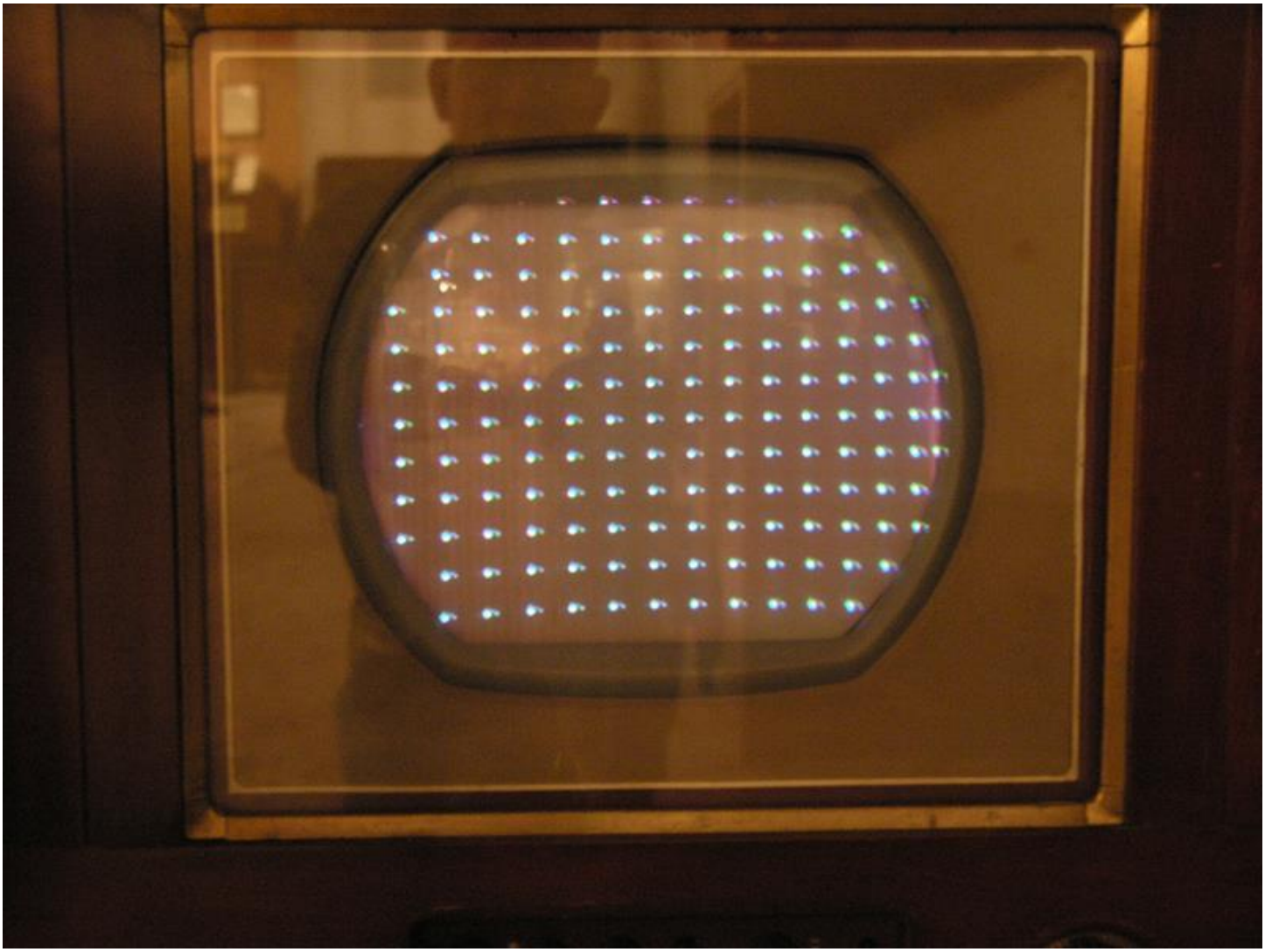
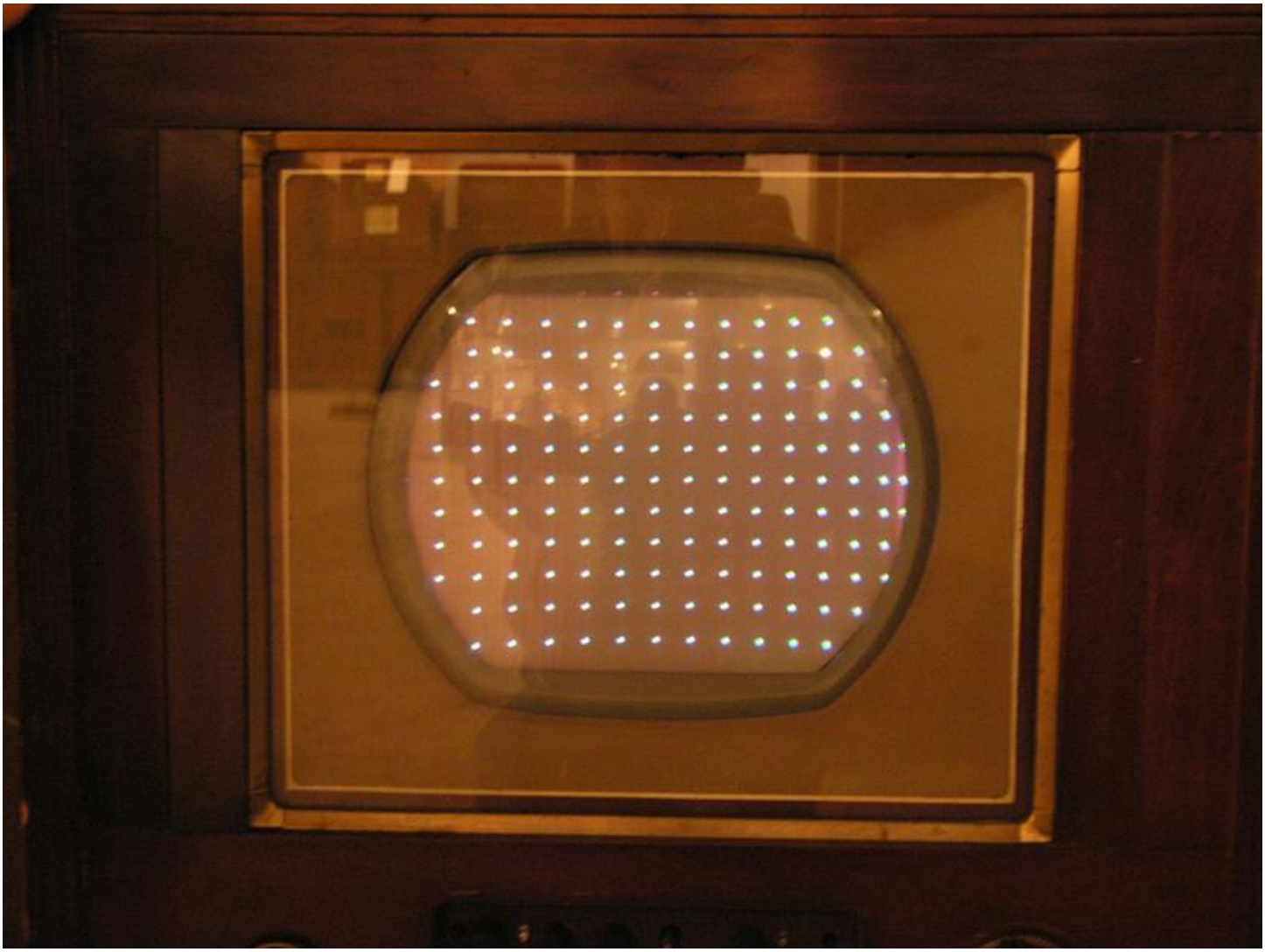
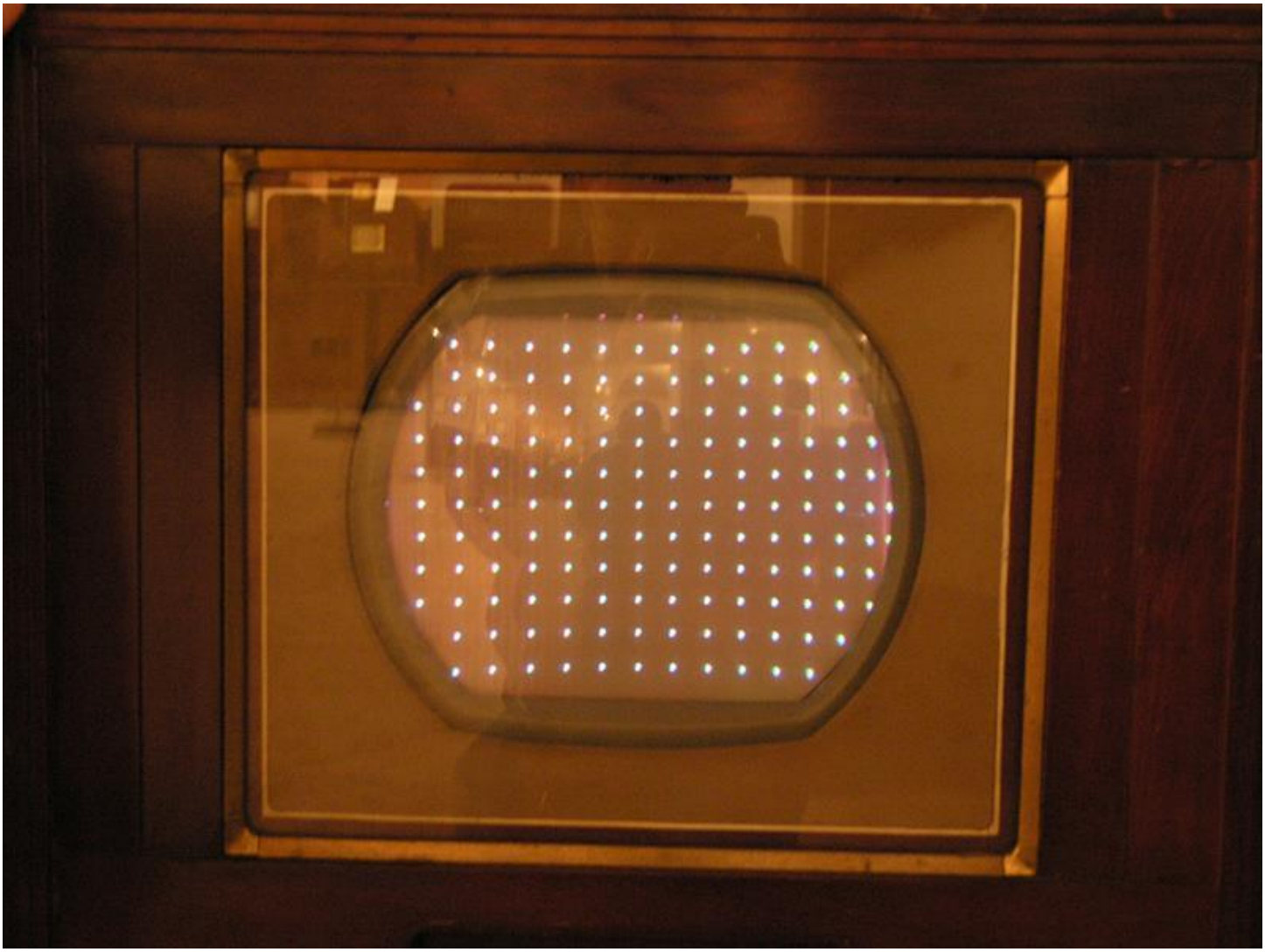
RCA

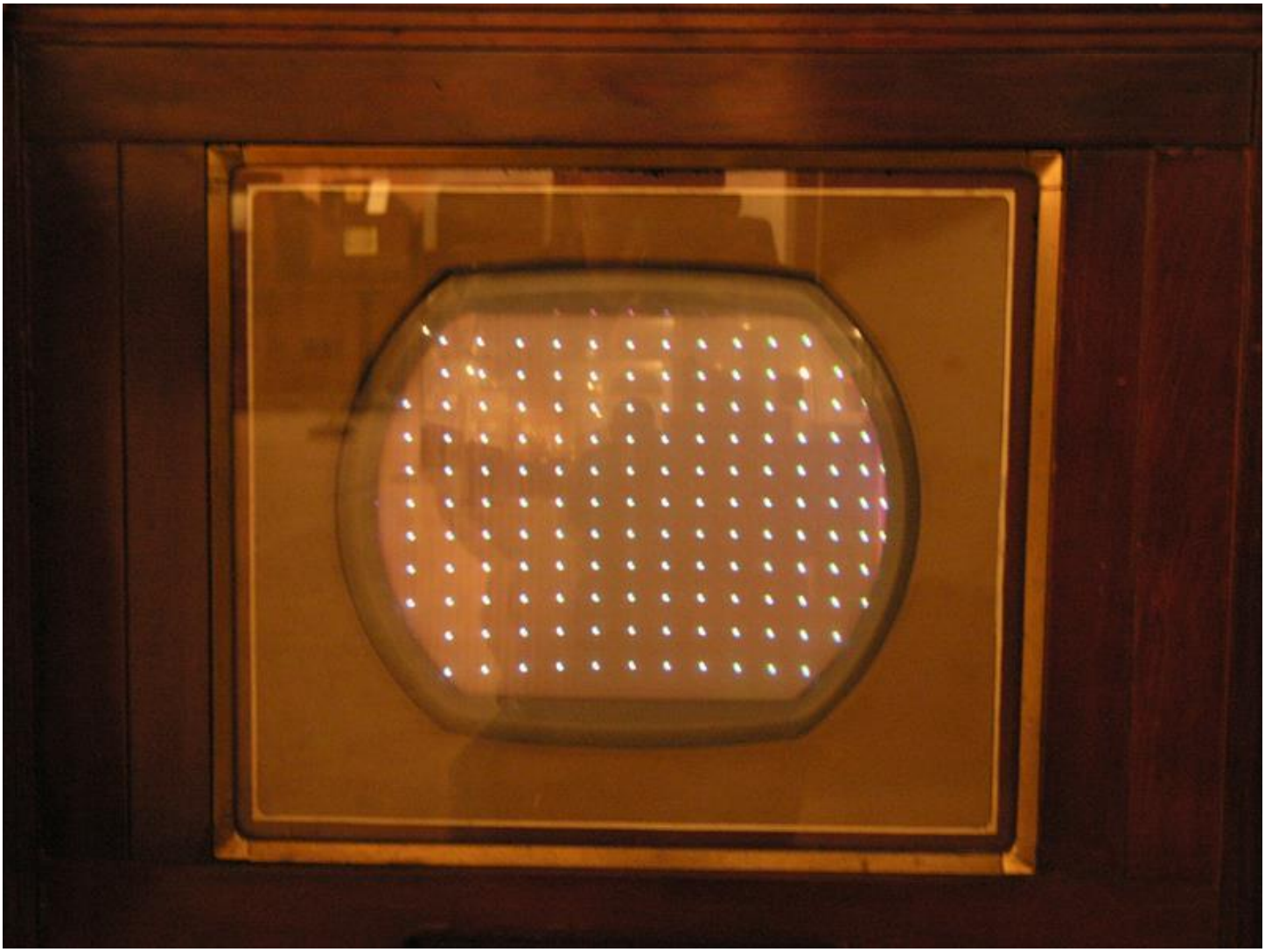

Tektronix












ZENITH


ZENITH


ZENITH


ZENITH
COLOR TV
Motorola 19CK2


ZENITH
COLOR TV


Admiral
FIRST
IN TELEVISION


PINKPILS
R-13


R-13
3½"
PINKPLUS
R-13


UPS
UPS


Pics
File Edit View Favorites Tools Help
Back
Search
Folders
Go
Address D:\Pics
Folders
Desktop
My Documents
My Computer
SQ00399-P05 (C:)
Pics (D:)
Pics
Control Panel
Shared Documents
Al's Documents
My Safe
My Network Places
Recycle Bin
My Safe
DSC_0001
DSC_0002
DSC_0003
DSC_0004
DSC_0005
DSC_0008
DSC_0009
DSC_0010
DSC_0011
DSC_0012
LENS SHIFT
FAST
SELECT : ENTER
Wireless Network Connection is now connected
Connected to: linksys(unsecured)
Signal Strength: No Signal
2:42 AM


REI


CROSLEY


EXIT
EXIT
RESTROOM
Rent Com, Inc.

Print
Edit with Fireworks
Edit

Rotate Clockwise
Rotate Counter Clockwise

Set as Desktop Background

Convert to Adobe PDF
Combine supported files in Acrobat...

Scan with AVG Anti-Spyware
Scan with AVG Free
Open With
Add to archive...
Add to "aaa.jpg.rar"
Compress and email...
Compress to "aaa.jpg.rar" and email

Send To

Delete

Properties

ENGINE COMPARTMENT
STEP
REFLECTOR
STORAGE
SEAT
SEAT
SEAT
HATCH
STORAGE
POWER CONTROL
STEP
OPERATOR'S TABLE
MOD SOUND
CABLE REELS
MASTER MONITOR
SWITCHING SYSTEM
CAM CONT.
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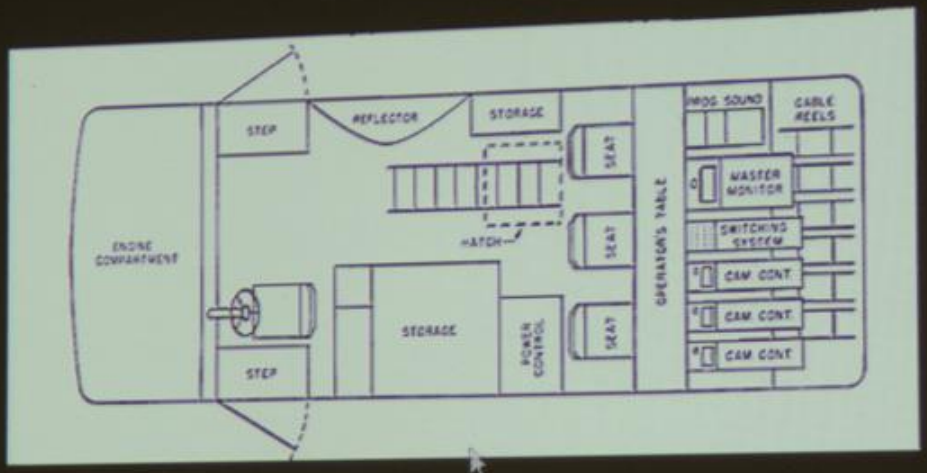
ENGINE COMPARTMENT
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SWITCHING SYSTEM
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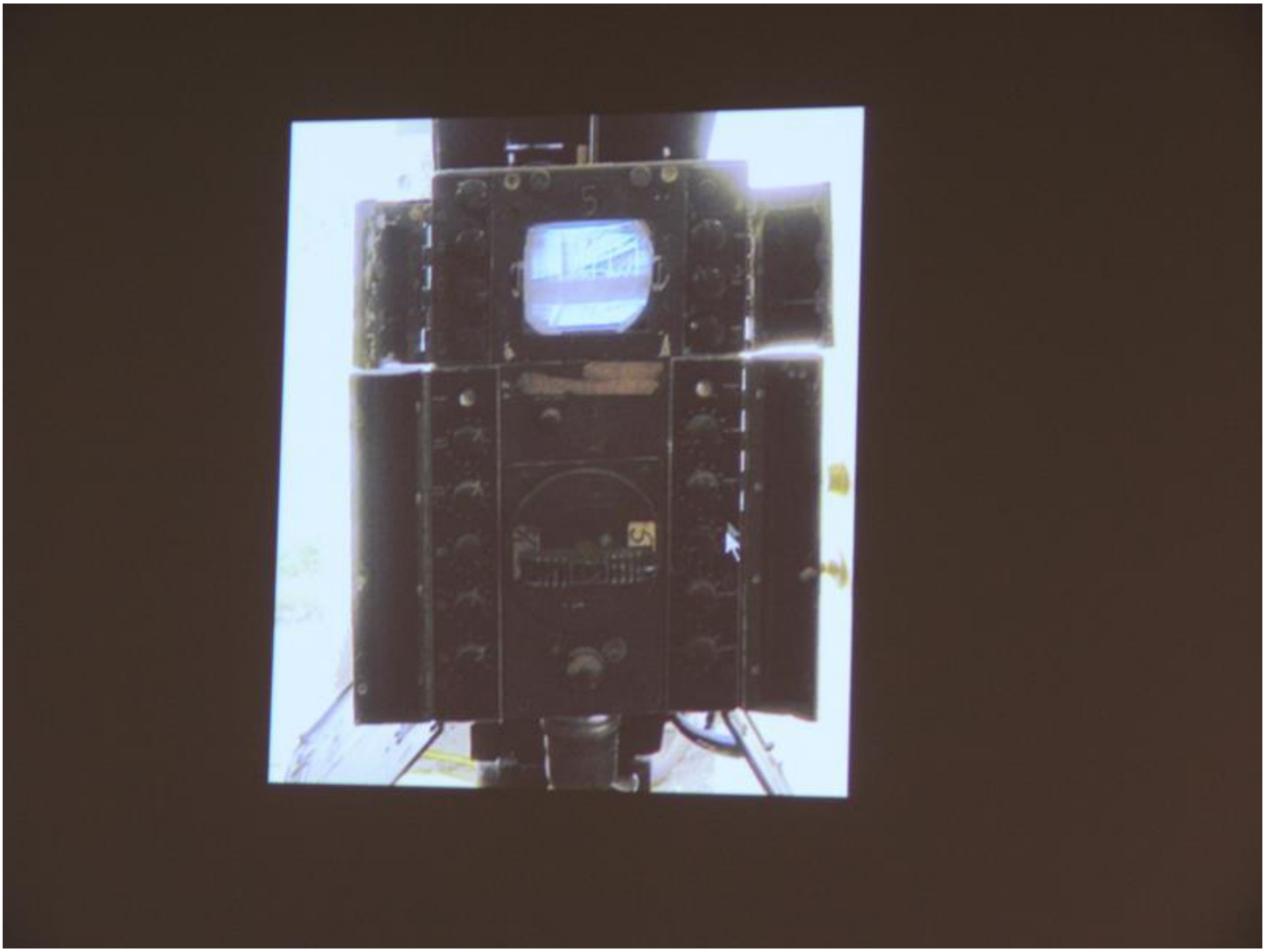
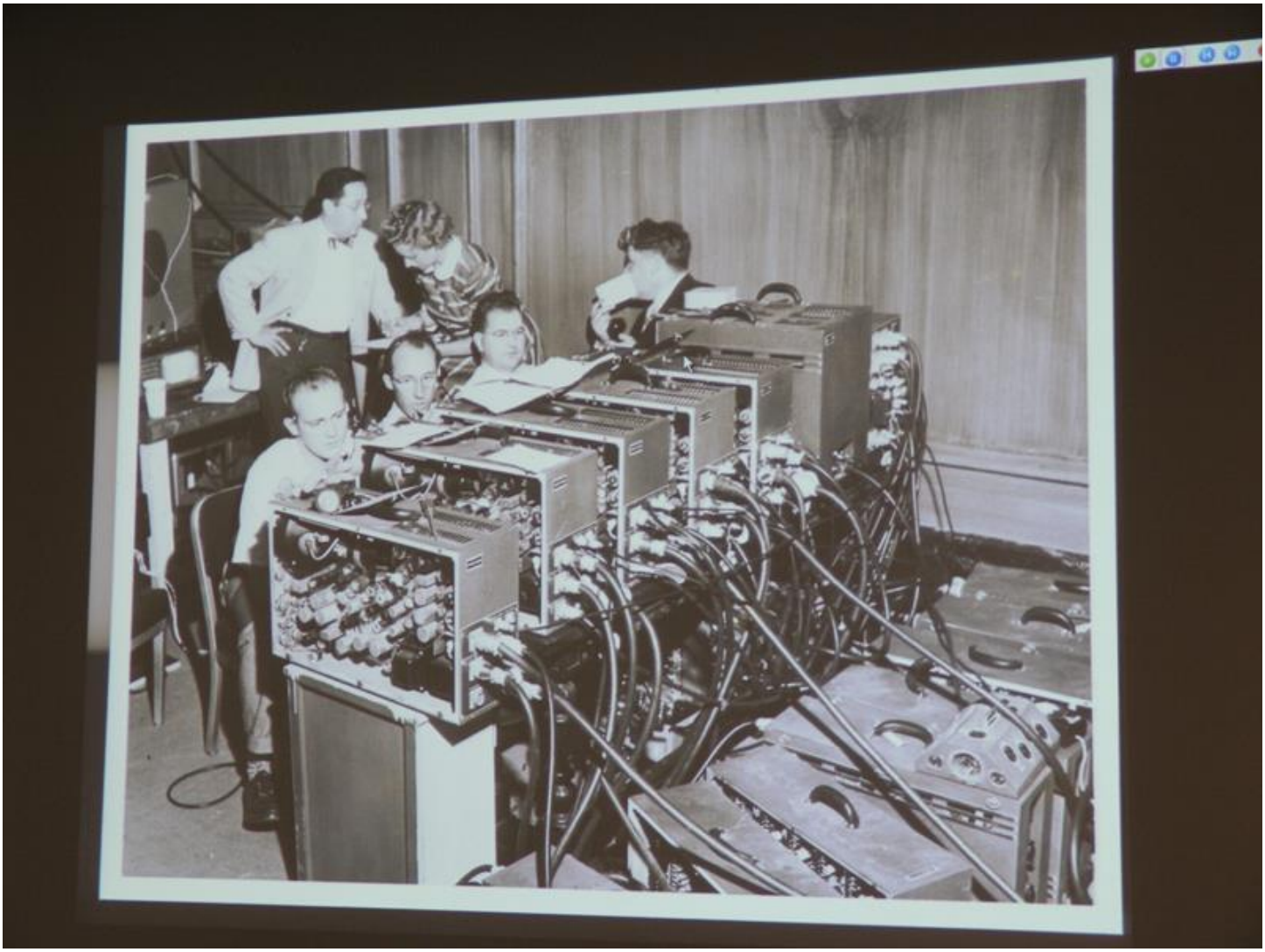
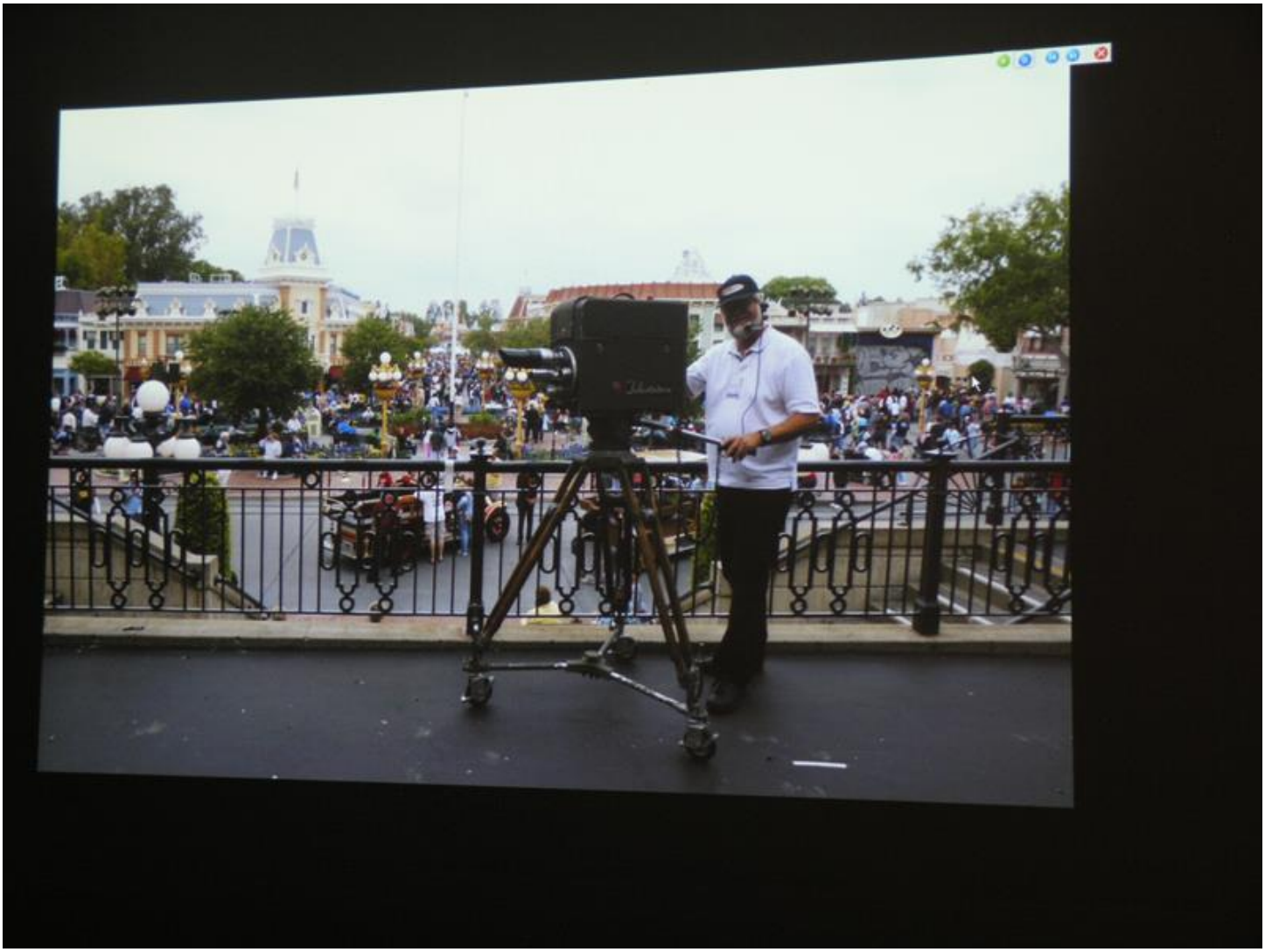
RCA

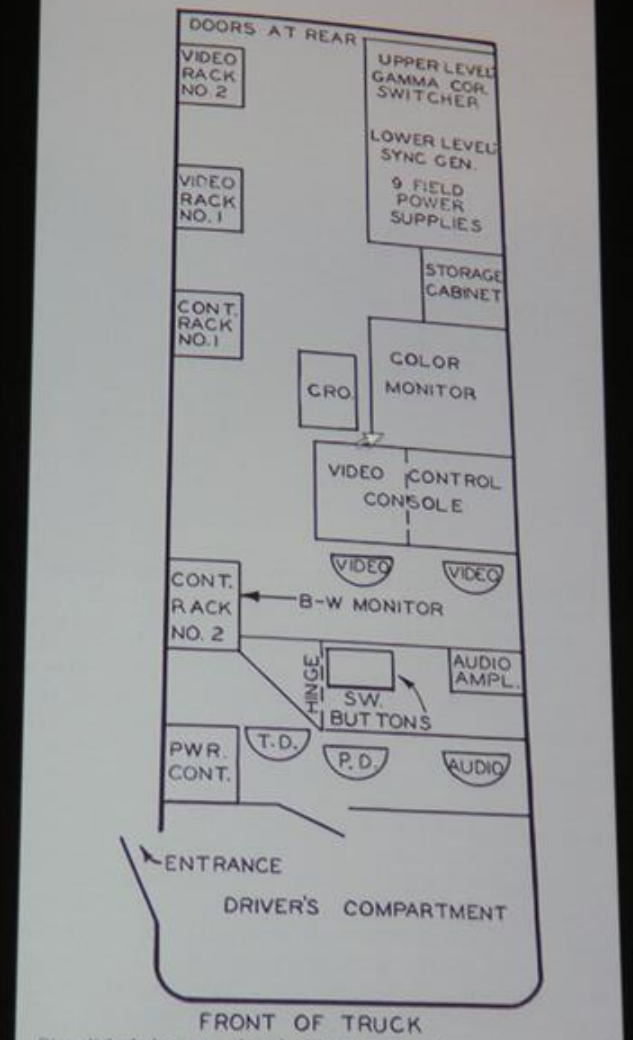




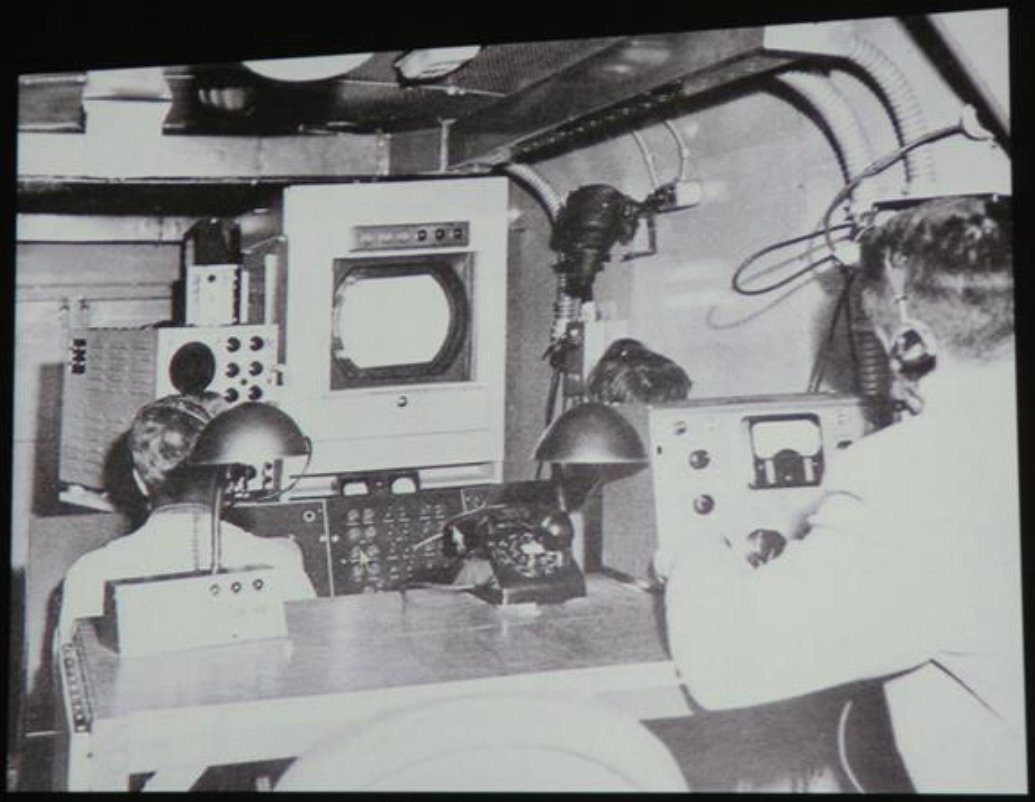

MAIN STREET
FRONTIER
FILM
TOMORROW
FANTASY
1
3




TELEVISION SYSTEM
RCA
NATIONAL BROADCAST
INC

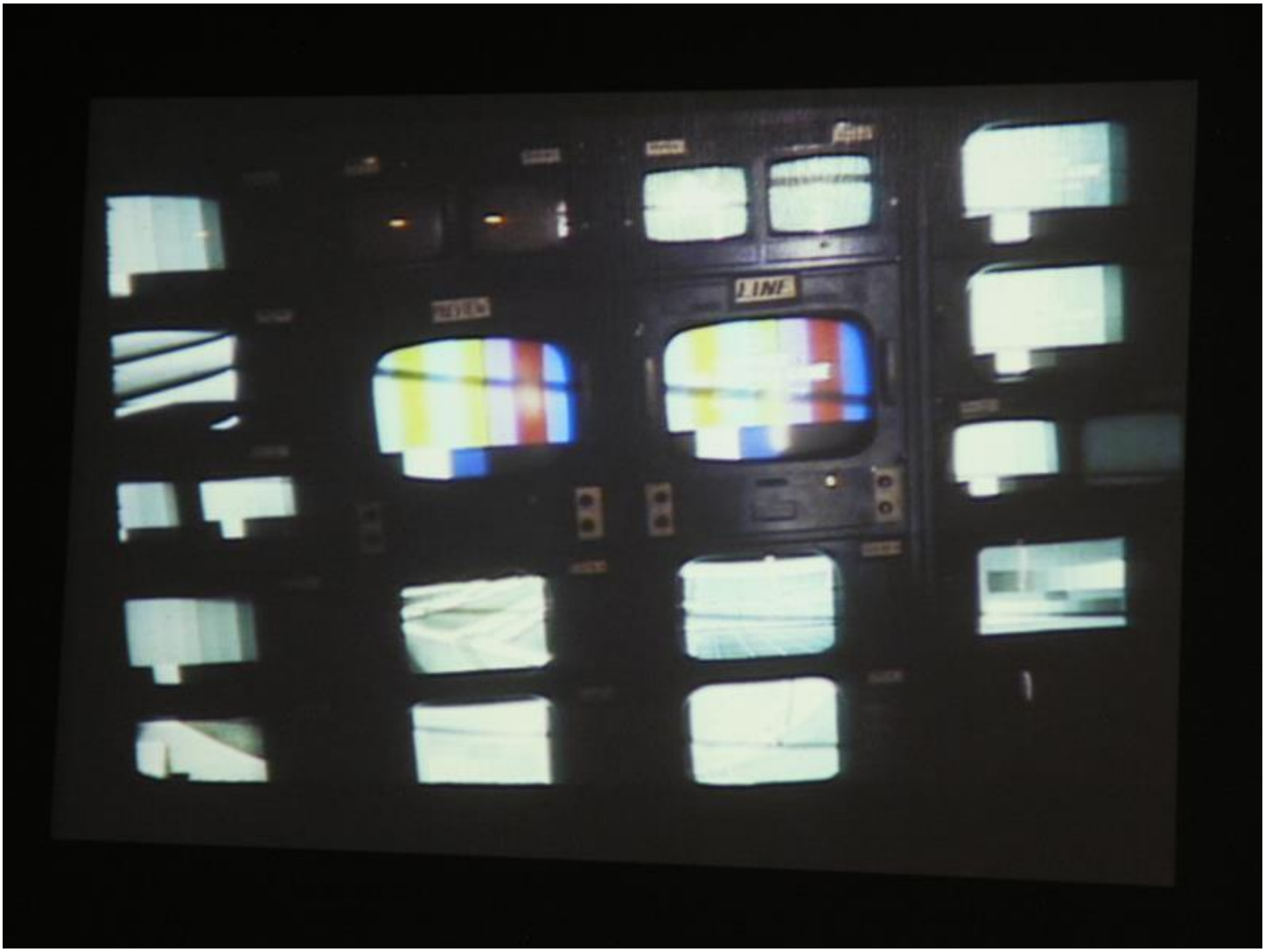


Simplified layout sketch illustrating the arrangement of




abc
abc


50
40
30
abc
abc


LINE

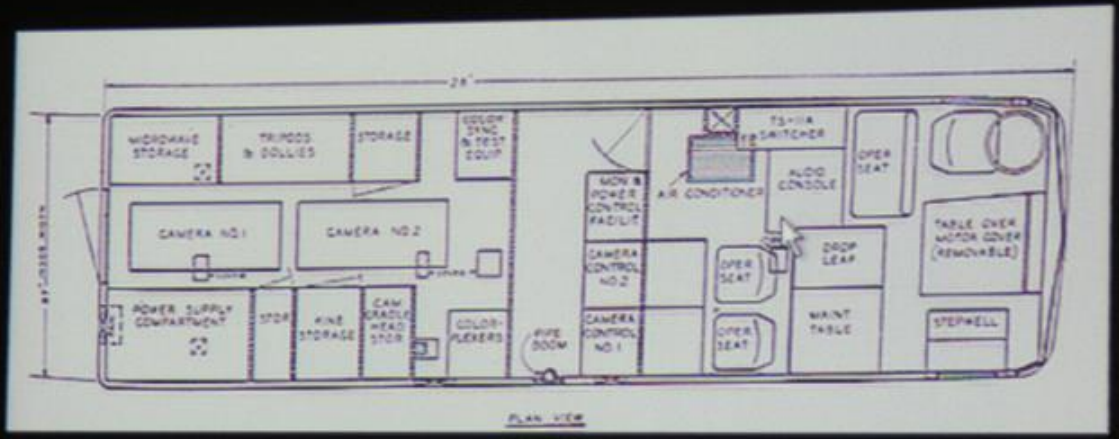
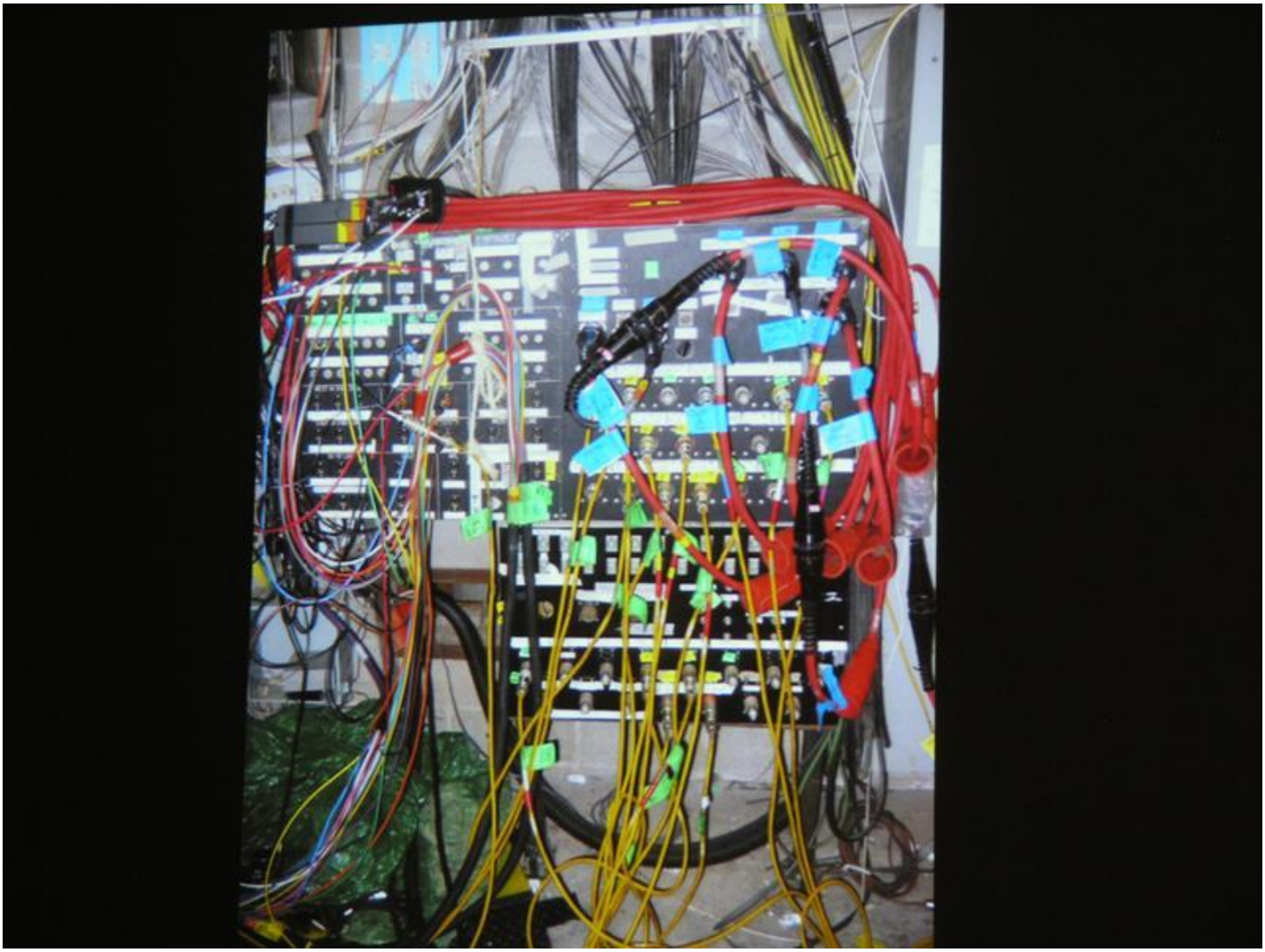
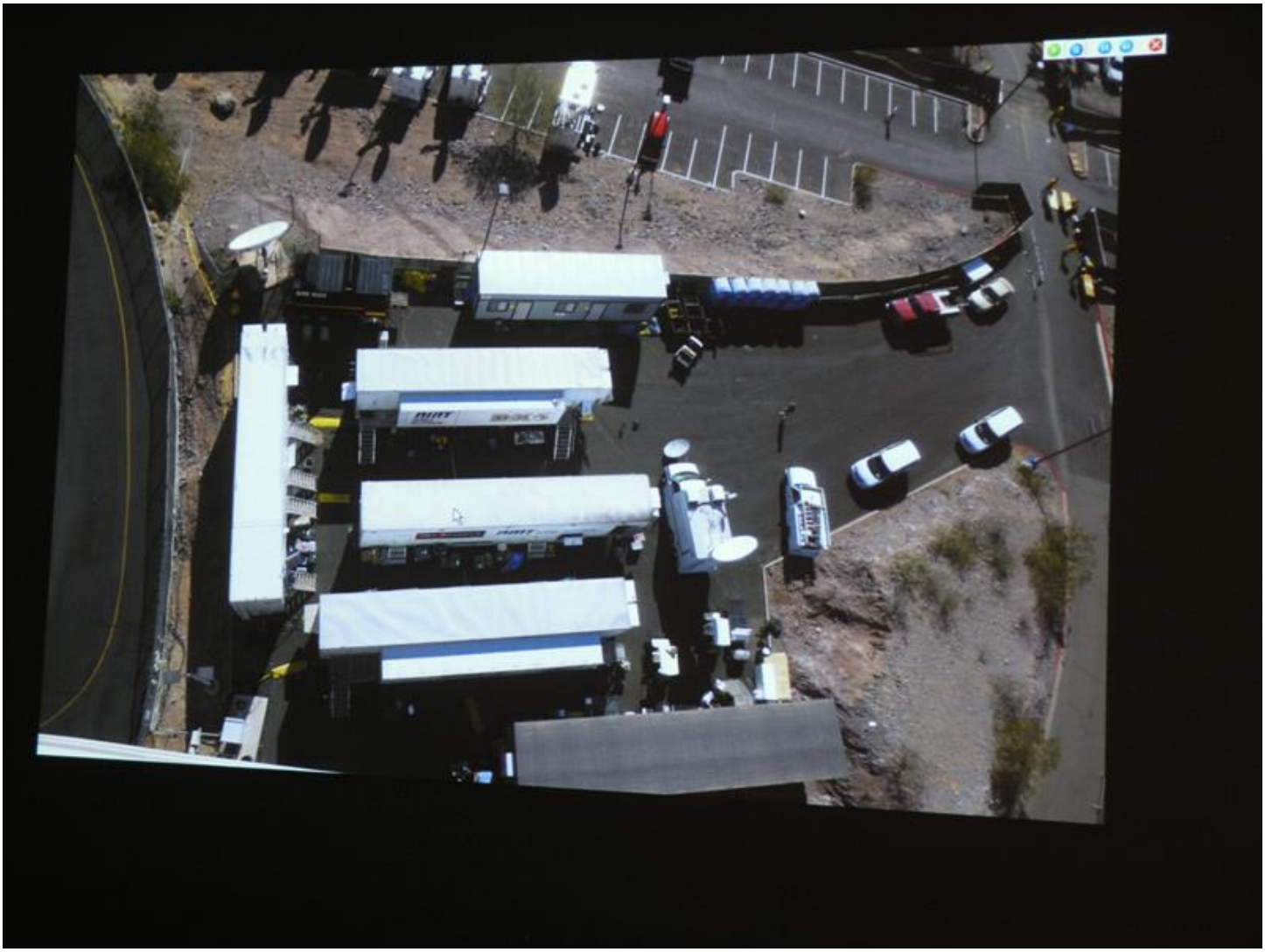

28'
MICROWAVE STORAGE
TRIPODS & DOLLIES
STORAGE
COLOR SYNC & TEST EQUIP
MON & POWER CONTROL FACILIT
AIR CONDITIONER
T3-HR SWITCHER
AUDIO CONSOLE
OPER SEAT
TABLE OVER MOTOR COVER (REMOVABLE)
CAMERA NO.1
CAMERA NO.2
CAMERA CONTROL NO.2
OPER SEAT
DROP LEAF
POWER SUPPLY COMPARTMENT
STOR
KINE STORAGE
CAM CRADLE HEAD STOR
COLOR-PLEXERS
FIRE DOOM
CAMERA CONTROL NO.1
OPER SEAT
MAINT TABLE
STEPWELL
PLAN VIEW

FIG. 1. Three Skelton RED EO TAPE Mobile Units. Control room bus is at left foreground, and the recording unit directly behind. The power and equipment storage bus is at right.


RED TAPE

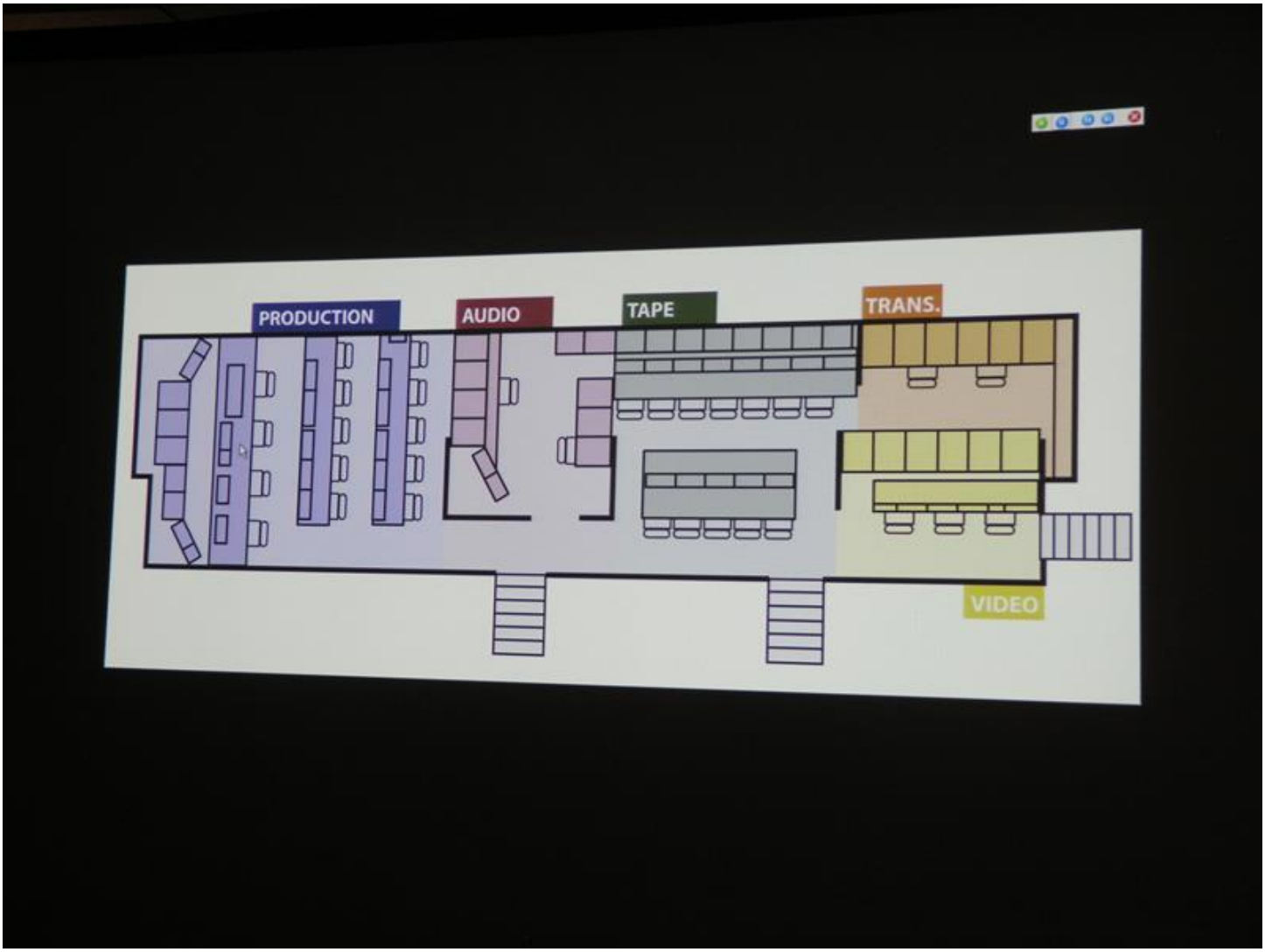


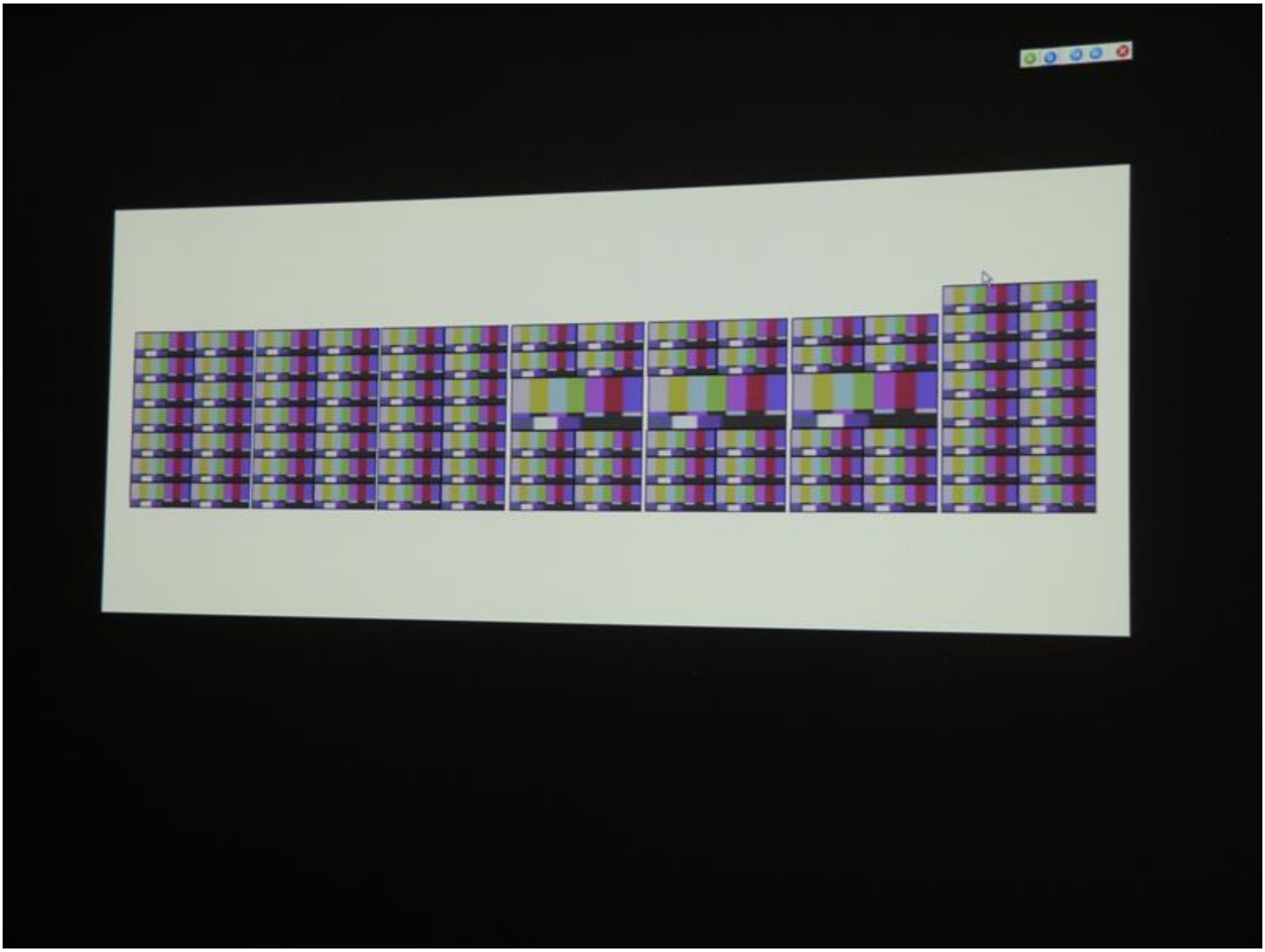

DASANI

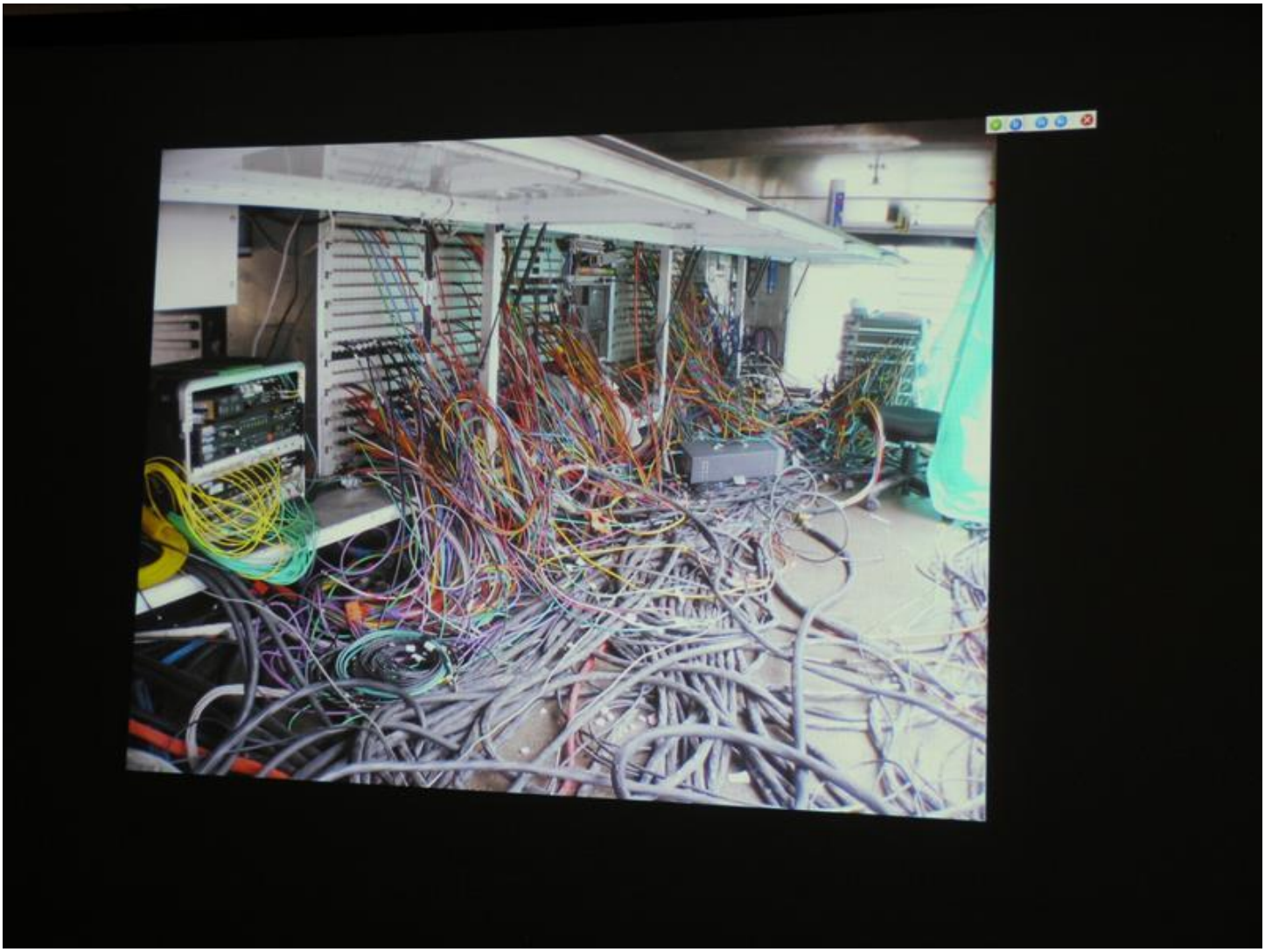


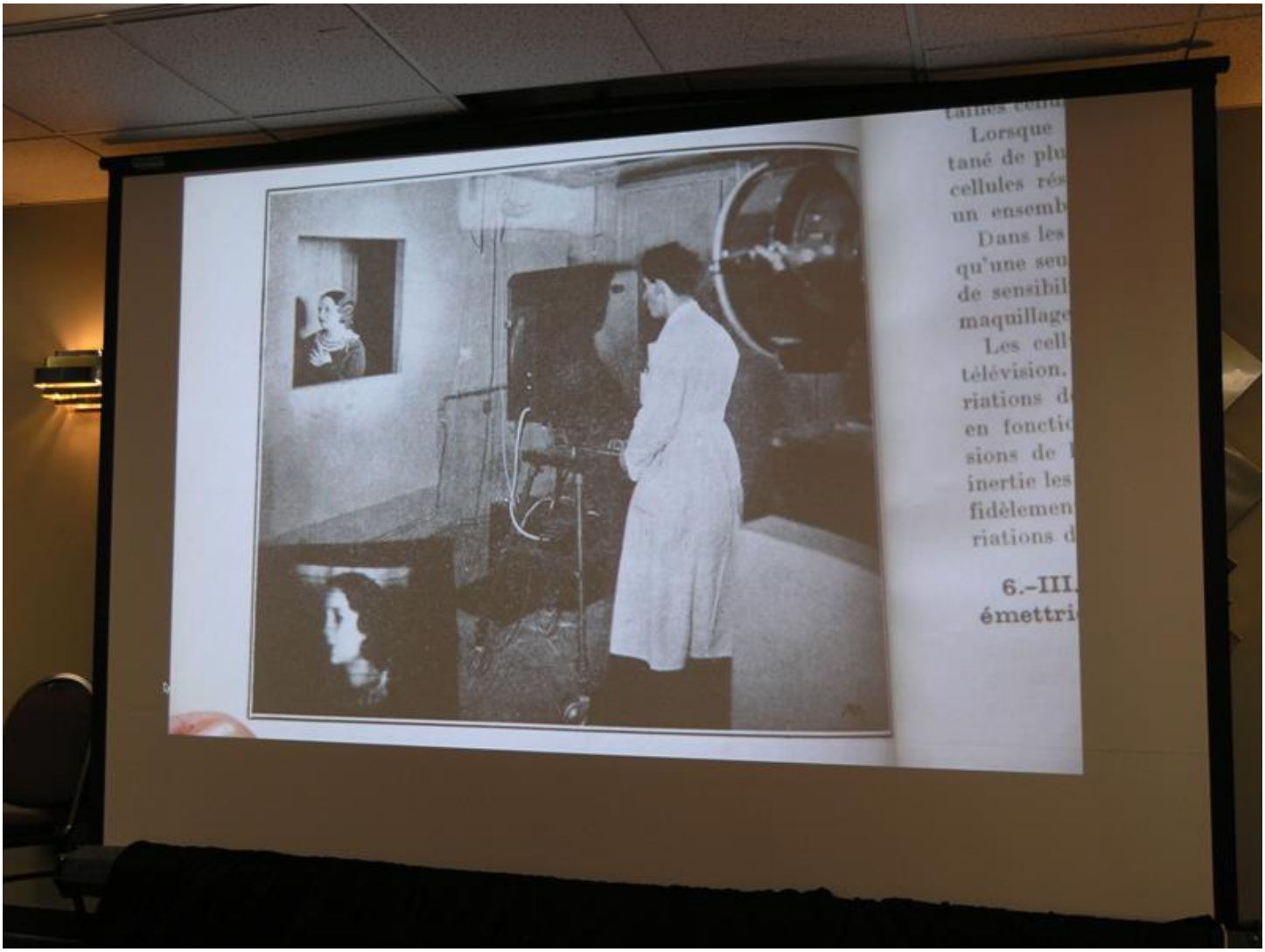

Panasonic
ooh, you gotta see it!


MONITOR TIME


PRODUCTION
AUDIO
TAPE
TRANS.
VIDEO






Lorsque
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Copyright
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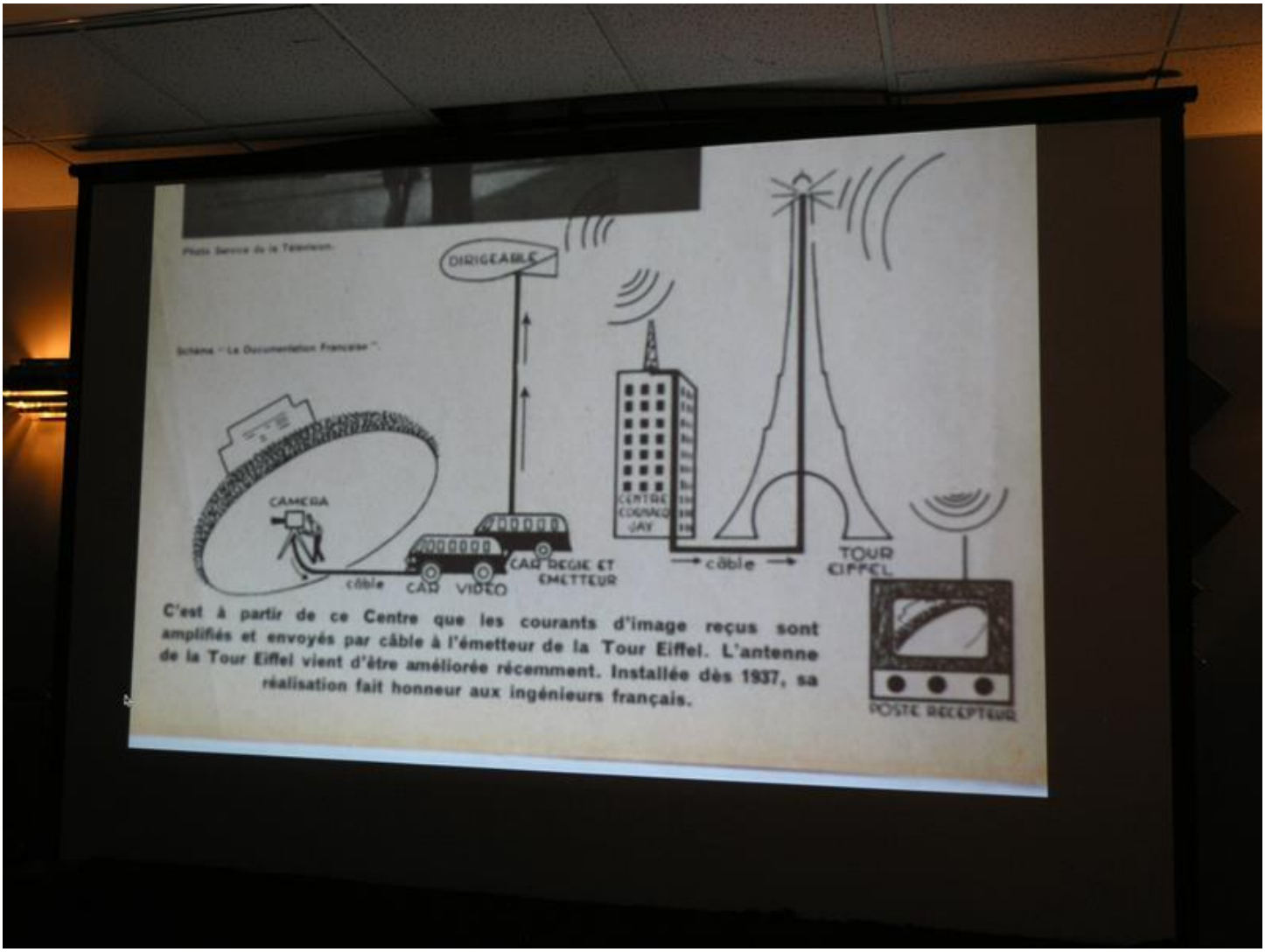
et du



C'est à partir de ce Centre que les courants d'image reçus sont amplifiés et envoyés par câble à l'émetteur de la Tour Eiffel. L'antenne de la Tour Eiffel vient d'être améliorée récemment. Installée dès 1937, sa réalisation fait honneur aux ingénieurs français.

y to

over-
here
irect

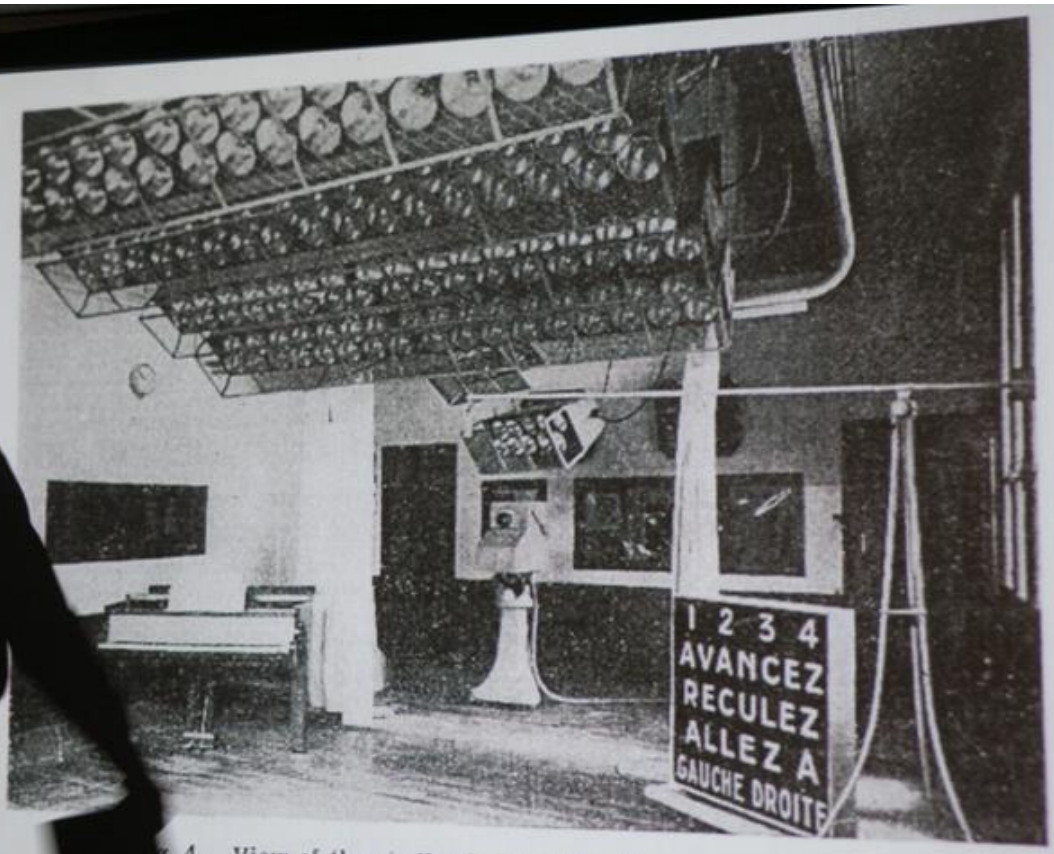


Fig. 4. View of the studio showing lighting arrangements

Iconoscope with an ordinary film projector. Scanning is effected at the rate of 50 demi-images per second

apparatus known as a mixer, the function of which it is to transmit to the various controls and to the transmitter one or other of the chosen scenes (direct pick-up or film transmissions) or gradual superposition of the two. In this manner some very interesting transitions can be obtained.

Distribution

The distribution lines, 10 in number, at the output of the mixer, are

modulates a push-pull H.F. stage comprising two water-cooled valves of 3 kW, is working on a quartz-controlled 8-metre wave.

The D.C. high tension (8,000 V.) is furnished by a mercury arc rectifier, and the auxiliary supplies by several groups of rotary generators. The total power consumption reaches 40 kWs, while the maximum power furnished to the feeder is from 6 to 8 kWs. This low efficiency is due to

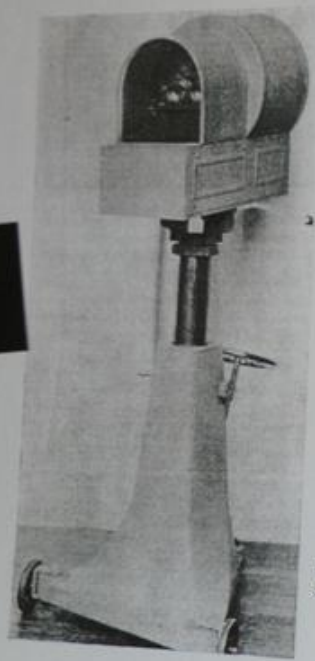


Fig. 5. (Left) Iconoscope camera for studio use.

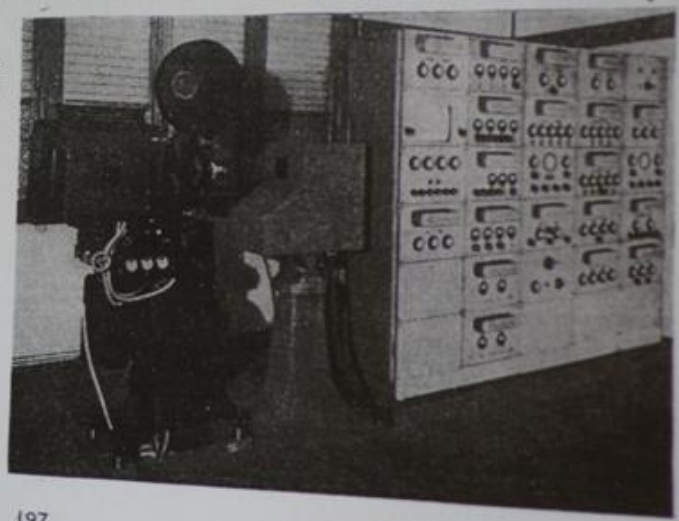


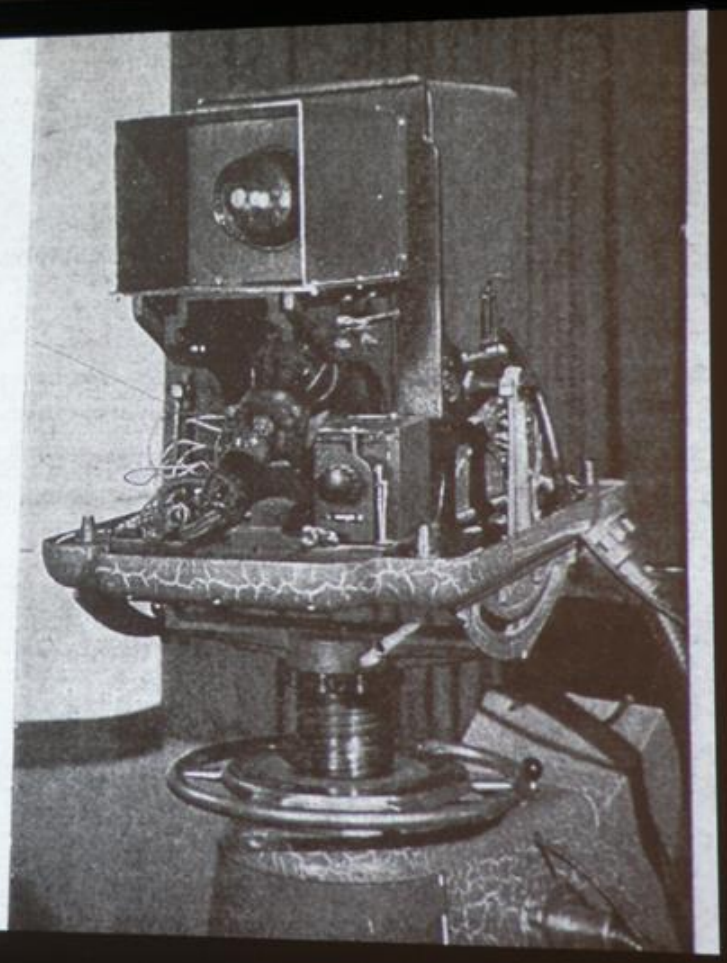
Fig 6. (Right) Film scanner and amplifier

is assez confortablement, quelles que
direction qu'il donne à la tête de sa
iger à prendre des positions qui, pour
sont pas moins incommodes, comme
employée dans les studios anglais ou
le caméraman fait pour ainsi dire corps
ans un modèle de caméra tout récent,
s (*figure* 7), les possibilités du viseur
beaucoup plus à fond ; un tel viseur
la tête de caméra sur une grue et on
s caméras télécommandées.

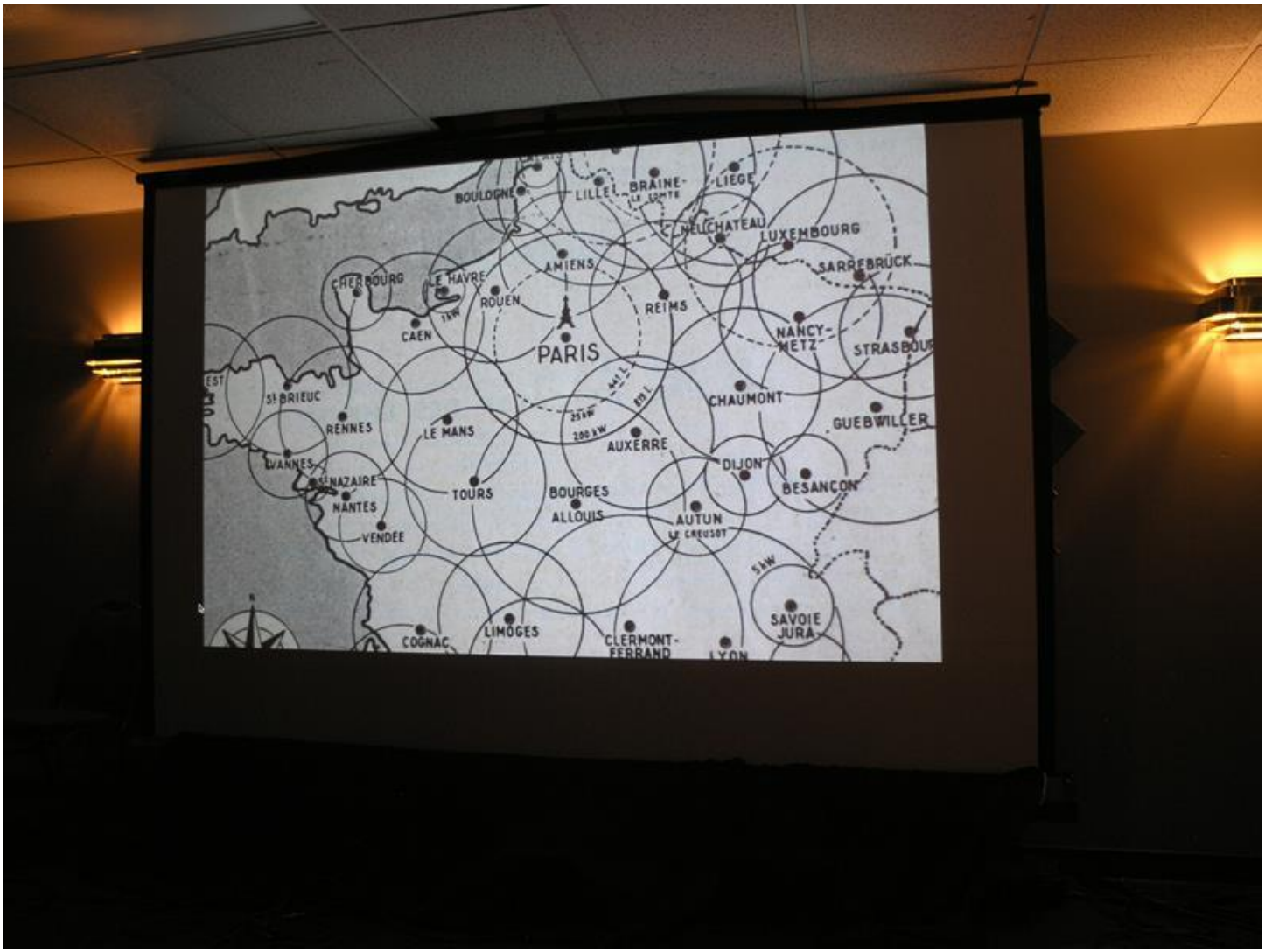
ieds de caméra sont montés sur roues
ements et le « travelling » ; au cours
des trépieds télescopiques analogues
ises de vues cinématographiques.

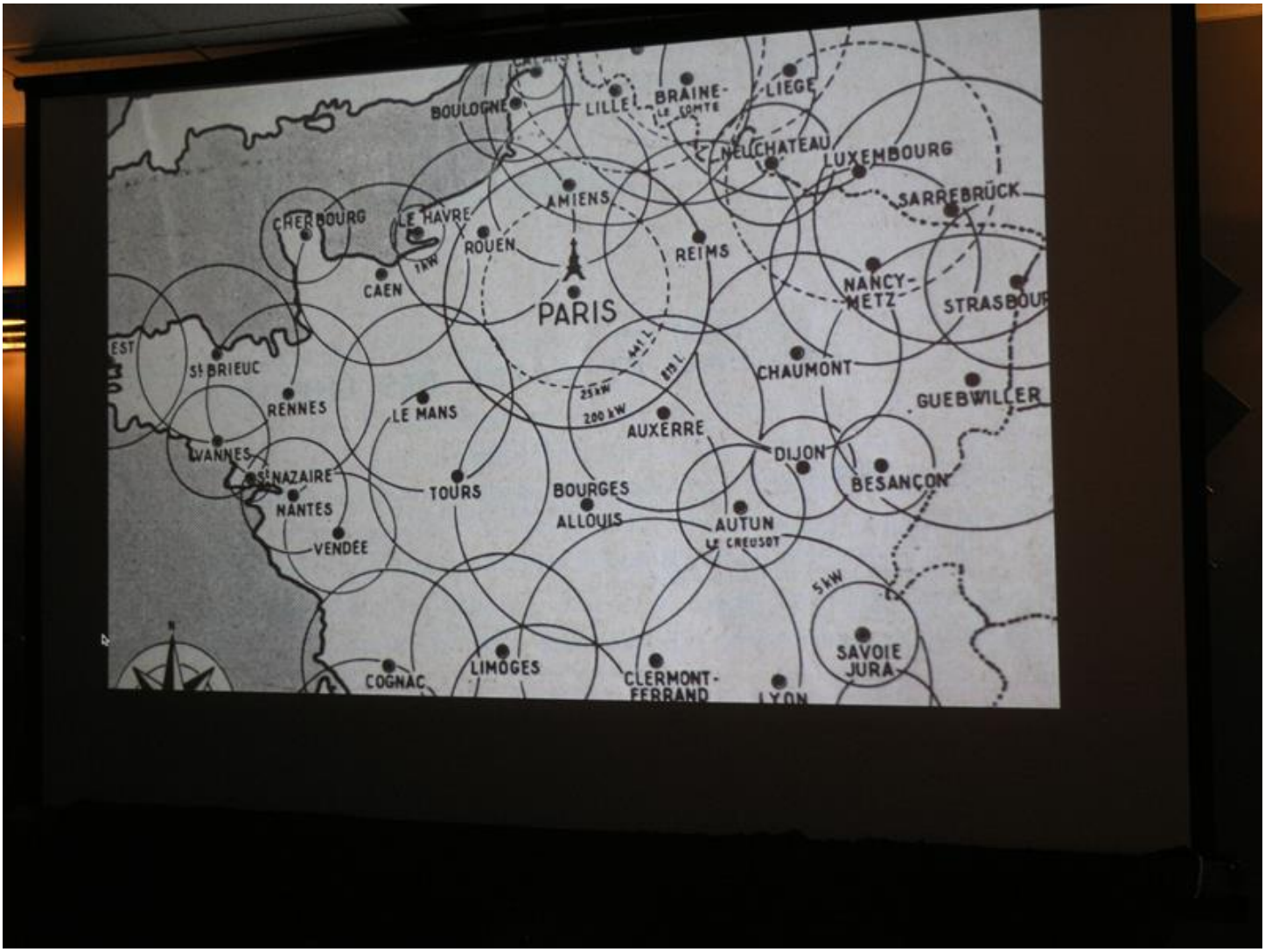
rectes nécessite, même pour la scène
simultanée d'au moins deux caméras
u spectateur des images suffisamment
imposer de suivre constamment les
. Le choix, entre toutes les images
t passer sur l'antenne à un instant
« mélangeur d'images », opérateur
l appelé « régie », dont nous repar-

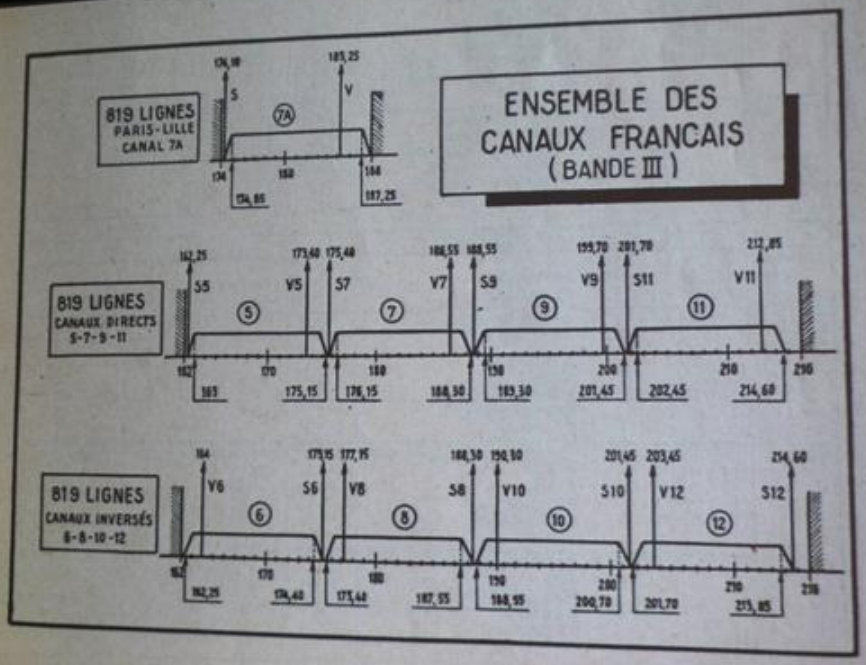
varie avec le tube de prise de vues
plusieurs milliers de lux sont néces-
cope et l'orthicon se contentent de
mage-orthicon, on peut descendre à
btenir une image au clair de lune.
utilisables sont variées ; il faut
un spectre de raies, comme les
rare ; elles donneraient, en effet,
correspondant à la fréquence des
ur les autres couleurs. Toutes les
employées : les lampes à incan-
es dans des projecteurs à lentille

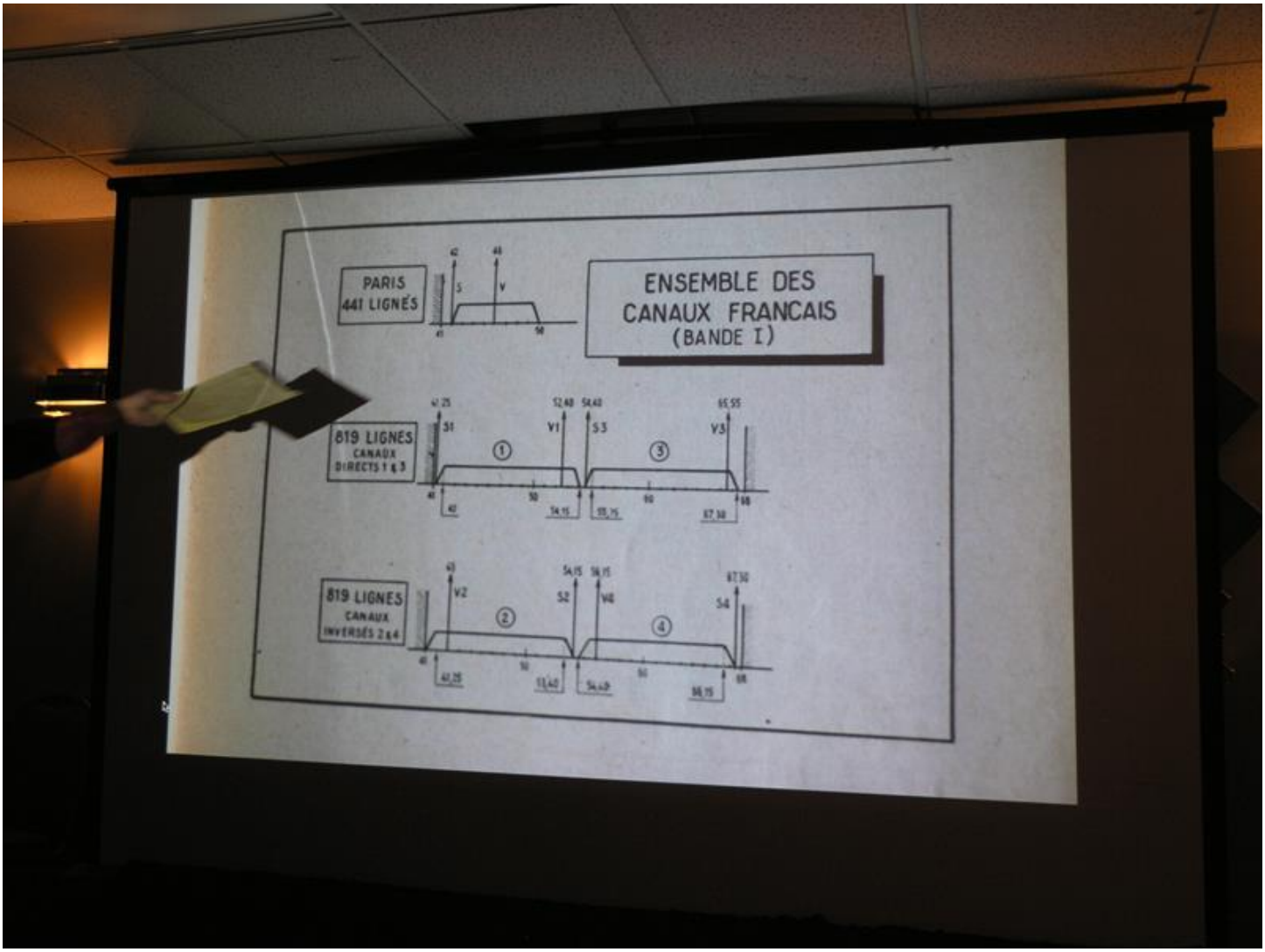


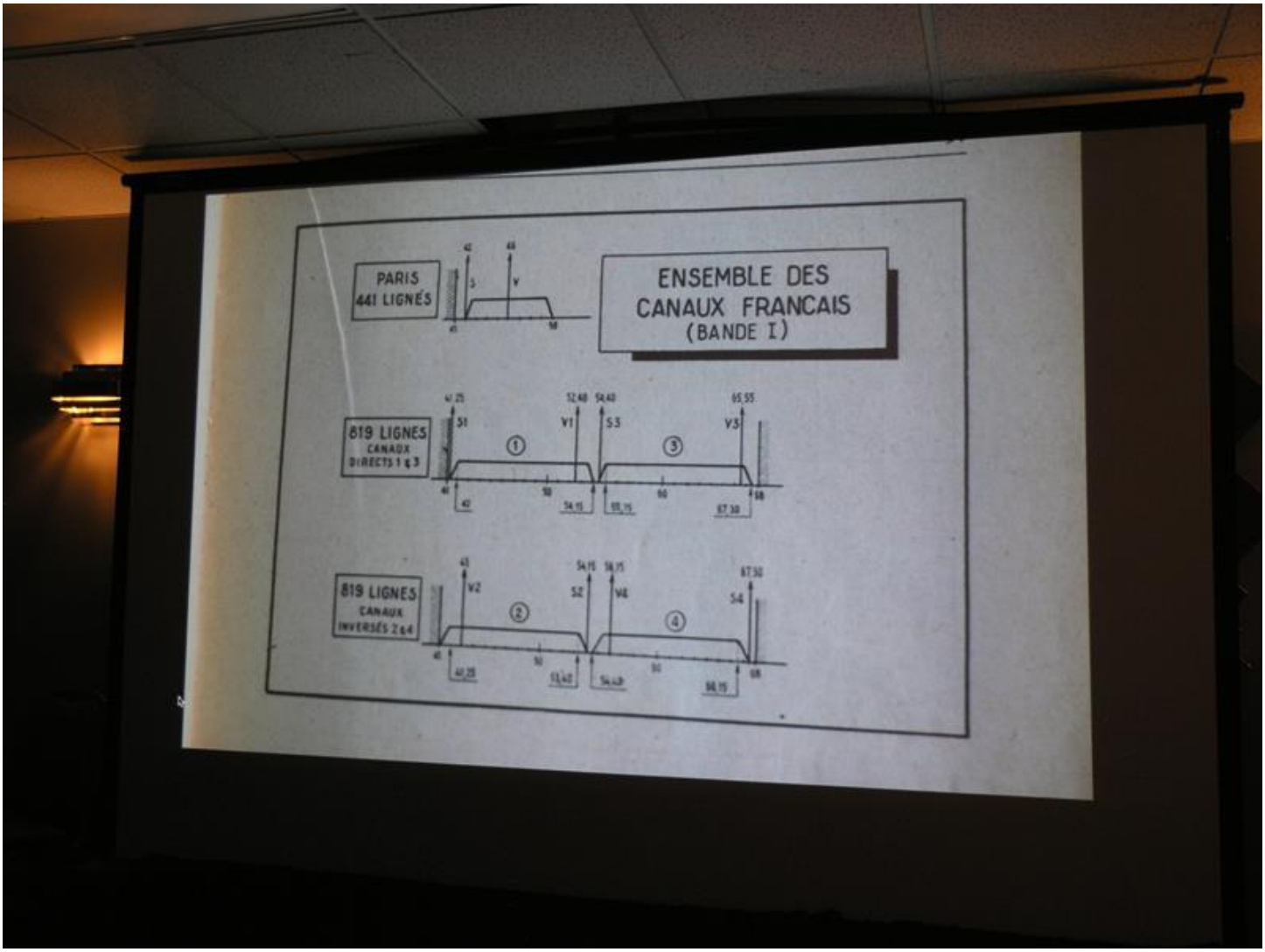
Caméra de studio de la C.D C. (Photo G. ROUQUET).


BOULOGNE
LILLE
BRAINE-
LIEGE
NEUFCHATEAU
LUXEMBOURG
AMIENS
SARREBRÜCK
CHERBOURG
LE HAVRE
ROUEN
REIMS
CAEN
PARIS
NANCY-
METZ
STRASBOUR
ST BRIEUC
CHAUMONT
RENNES
LE MANS
GUEBWILLER
AUXERRE
VANNES
DIJON
ST NAZAIRE
TOURS
BOURGES
BESANÇON
NANTES
ALLOUIS
AUTUN
VENDÉE
SAVOIE
JURA
COGNAC
LIMOGES
CLERMONT-
FERRAND
LYON


BOULOGNE
LILLE
BRAINE-LE COMTE
LIEGE
NEUFCHATEAU
LUXEMBOURG
SARREBRÜCK
AMIENS
CHERBOURG
LE HAVRE
ROUEN
REIMS
CAEN
1kW
PARIS
NANCY-METZ
STRASBOURG
EST
St BRIEUC
441 L
419 L
25 kW
200 kW
CHAUMONT
RENNES
LE MANS
AUXERRE
GUEBWILLER
VANNES
St NAZAIRE
DIJON
BESANÇON
TOURS
BOURGES
NANTES
ALLOUIS
AUTUN
LE CREUSOT
VENDÉE
5 kW
SAVOIE JURA
COGNAC
LIMOGES
CLERMONT-FERRAND
LYON


ENSEMBLE DES
CANAUX FRANCAIS
(BANDE III)
819 LIGNES
PARIS-LILLE
CANAL 7A
819 LIGNES
CANAUX DIRECTS
5-7-9-11
819 LIGNES
CANAUX INVERSÉS
6-8-10-12


ENSEMBLE DES
CANAUX FRANCAIS
(BANDE I)
PARIS
441 LIGNES
819 LIGNES
CANAUX
DIRECTS 1 & 3
819 LIGNES
CANAUX
INVERSÉS 2 & 4


PARIS
441 LIGNES
ENSEMBLE DES
CANAUX FRANCAIS
(BANDE I)
819 LIGNES
CANAUX
DIRECTS 1 & 3
819 LIGNES
CANAUX
INVERSÉS 2 & 4

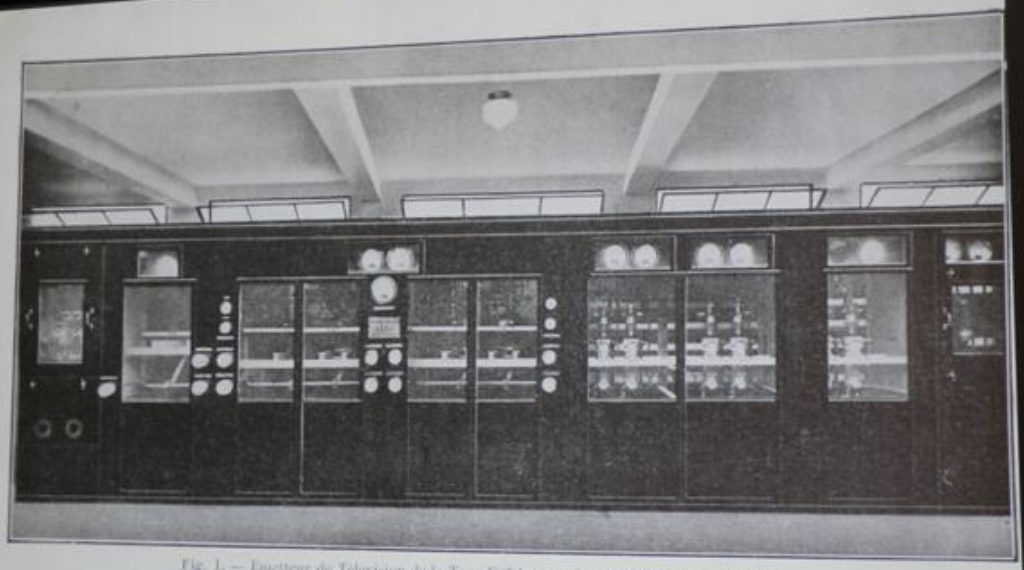
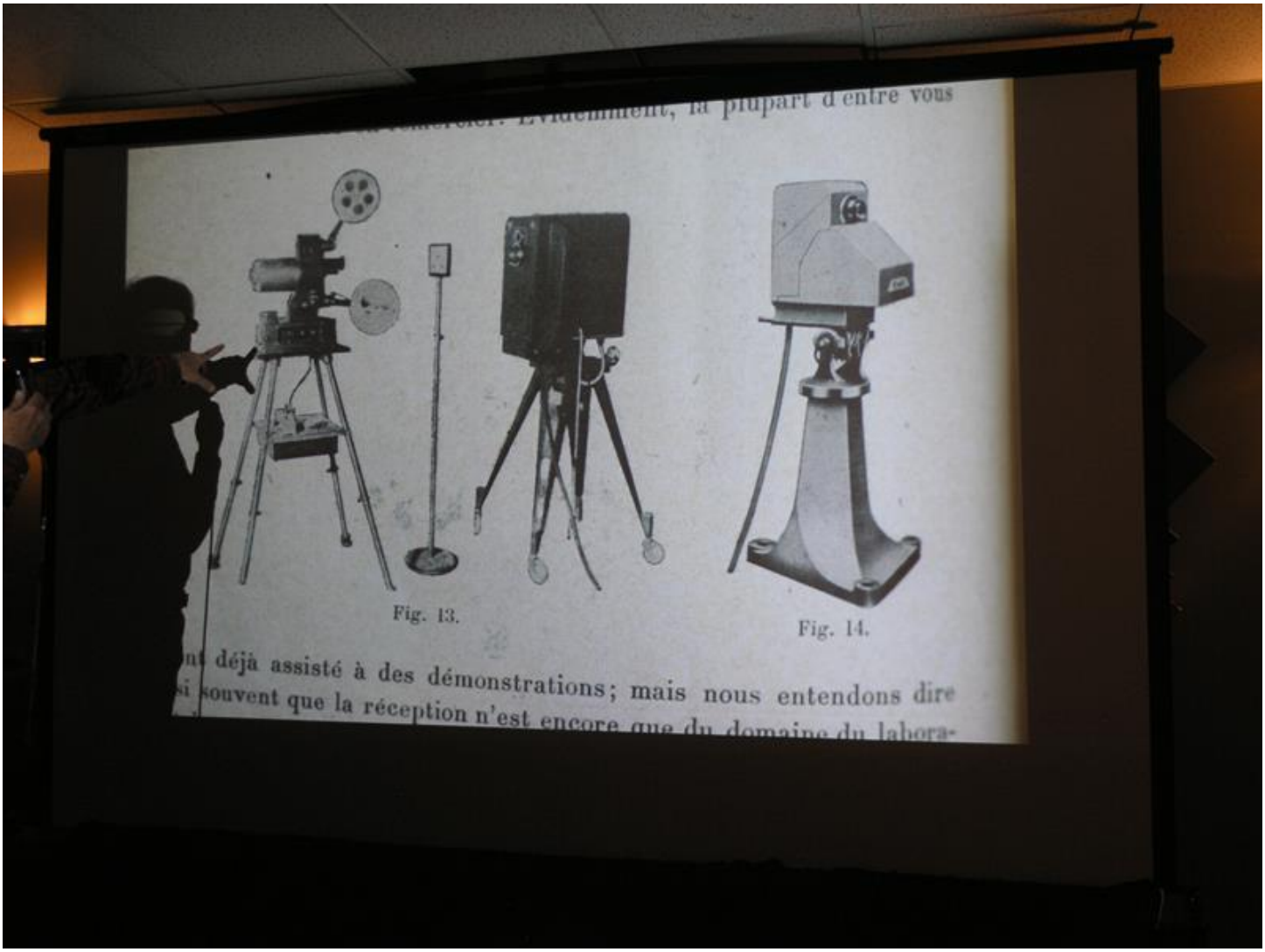


Fig. 1. — Emetteur de Télévision de la Tour Eiffel ayant fourni 38 Kw. utiles sur 8 m.



...Évidemment, la plupart d'entre vous

Fig. 13.

Fig. 14.

...nt déjà assisté à des démonstrations; mais nous entendons dire
...si souvent que la réception n'est encore que du domaine du labora-

che la même activité, il est hors de doute qu'envers et contre tous la télé-

45°. De cette façon, une trentaine de personnes peuvent voir simultanément

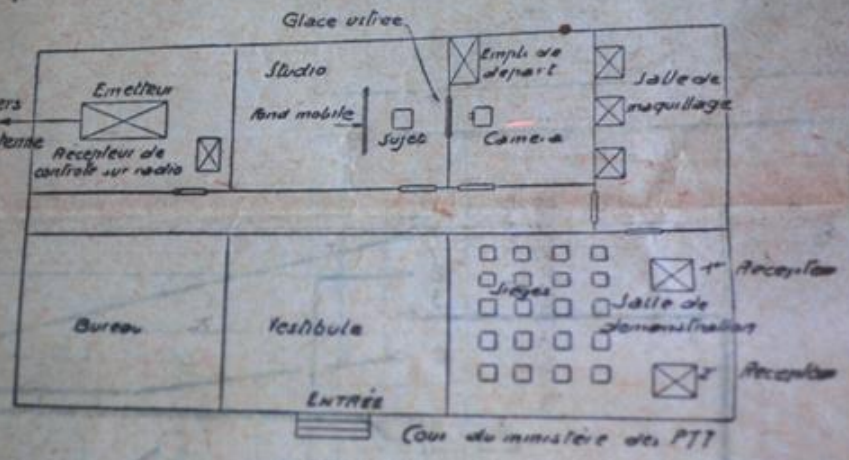


Fig. 1

vision se développera en France, et plus vite que les esprits chagrins et pessimistes (on sait pourquoi) veulent

la réception qui, bien entendu, est sonorisée.

J'ai renoncé, pour ma part, à avoir

che la même activité, il est hors de doute qu'envers et contre tous la télé-

45°. De cette façon, une trentaine de personnes peuvent voir simultanément

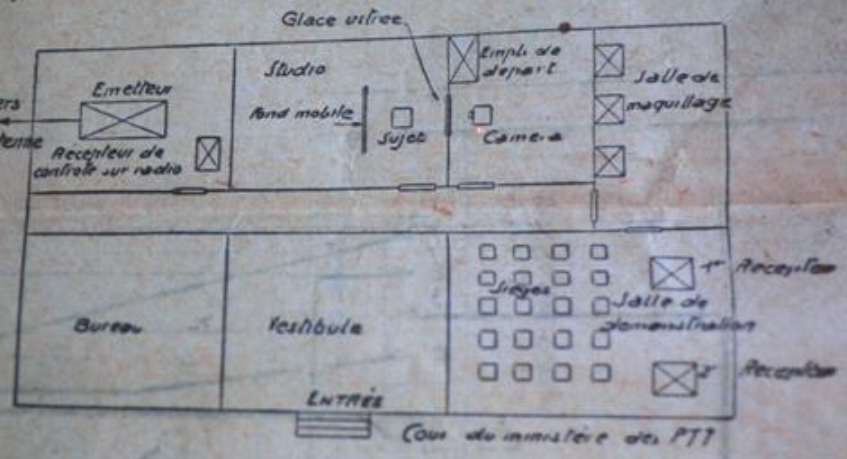
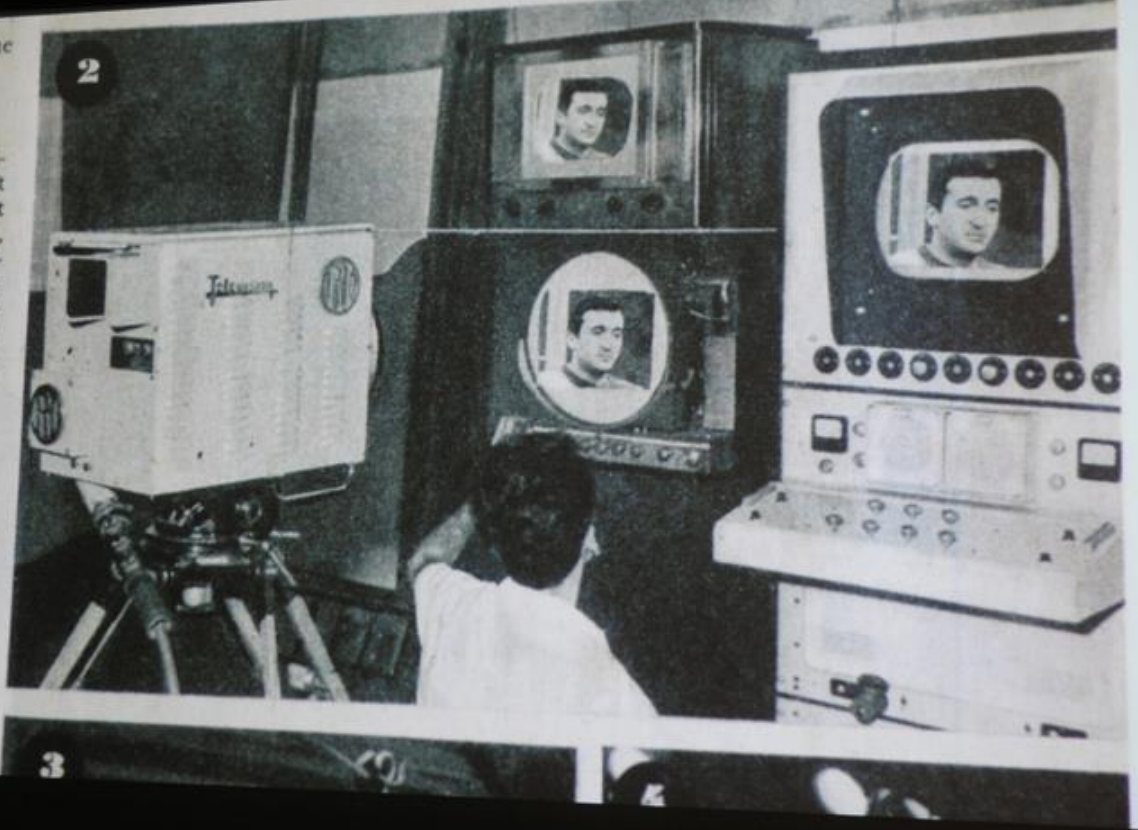


Fig. 1

vision se développera en France, et plus vite que les esprits chagrins et pessimistes (on sait pourquoi) veulent

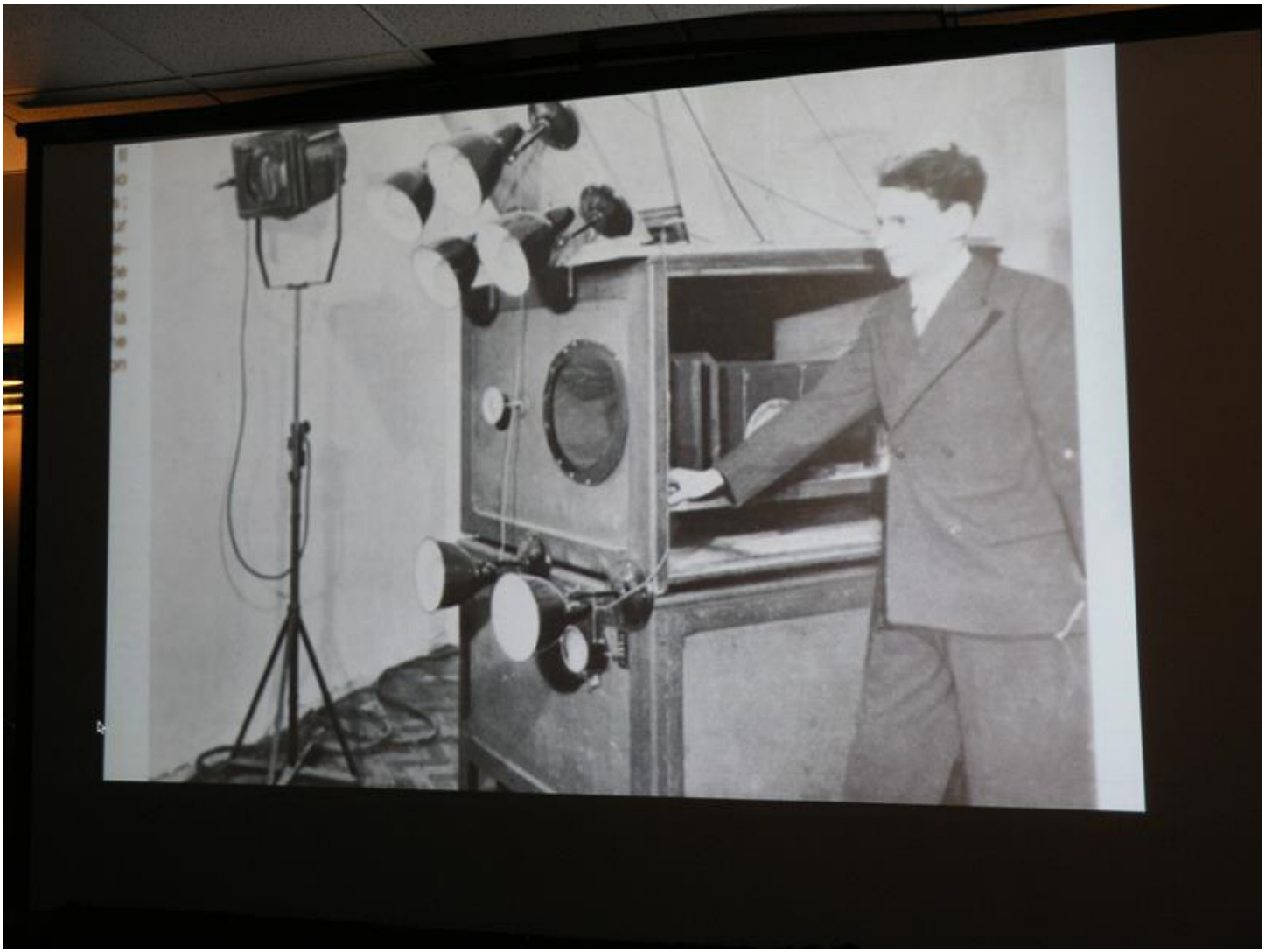
la réception qui, bien entendu, est sonorisée.

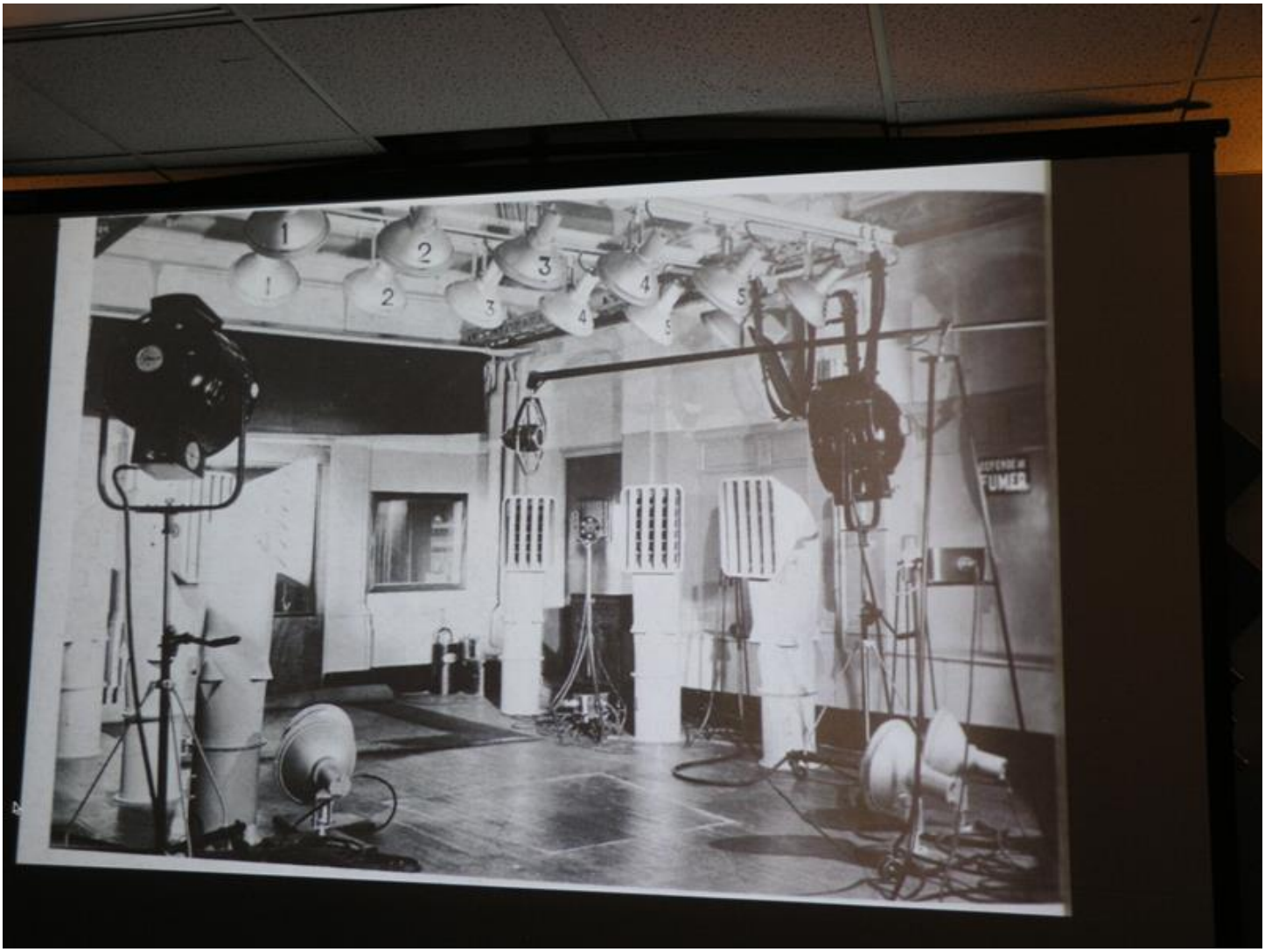
J'ai renoncé, pour ma part, à avoir

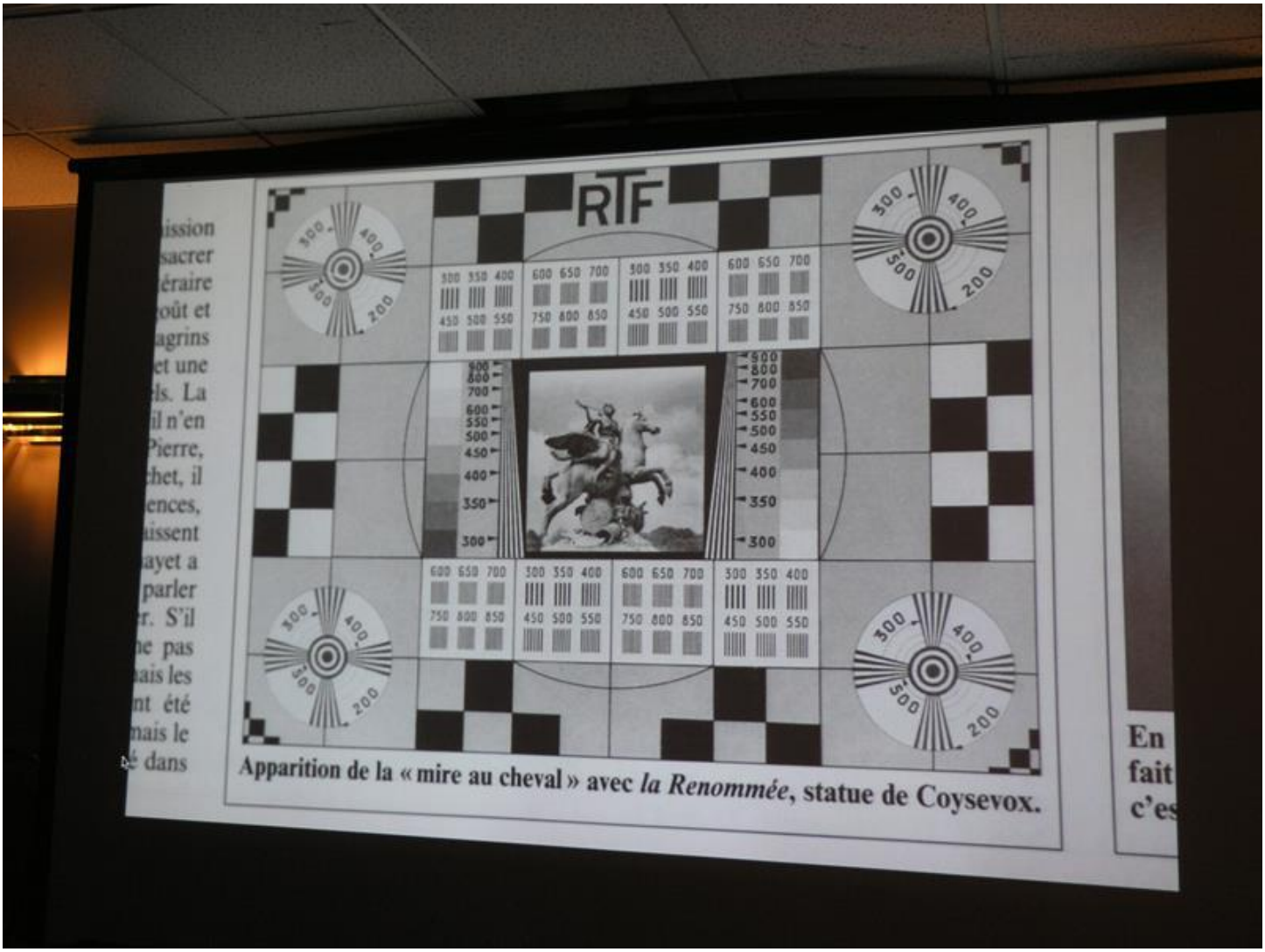


2

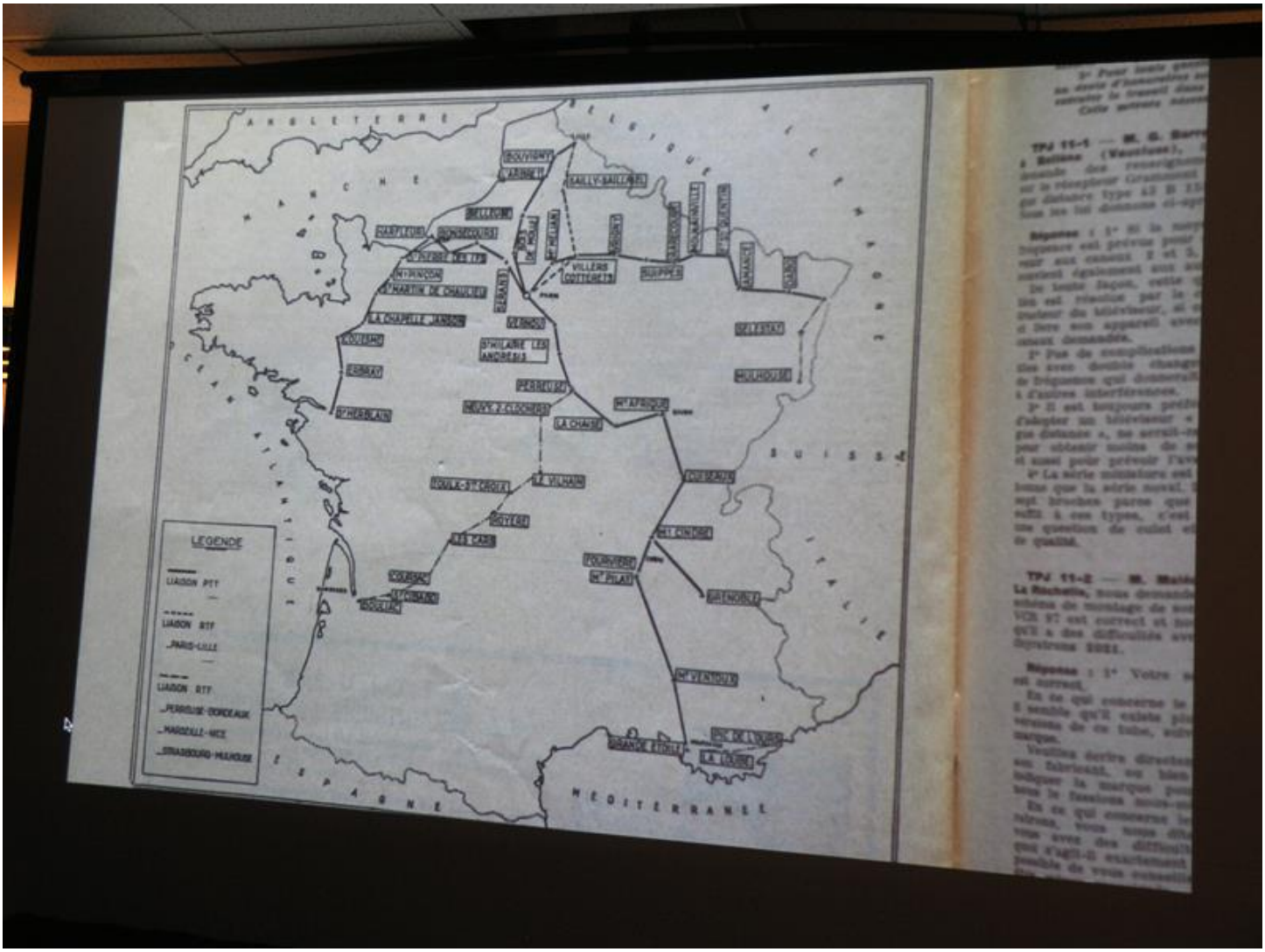
3




1
2
3
4
5
1
2
3
4
5


RTF
Apparition de la « mire au cheval » avec *la Renommée*, statue de Coysevox.


La caméra 180 lignes à disque «double spirale», mise au point par R. Barthélemy pour les émissions haute définition de décembre 1935.


ANGLETERRE
BELGIQUE
ALLEMAGNE
SUISSE
ITALIE
ESPAGNE
MÉDITERRANÉE
LEGENDE
LIAISON PTT
LIAISON RTF
PARIS-LILLE
LIAISON RTF
PERPIGNAN-BORDEAUX
MARSEILLE-NICE
STRASBOURG-MULHOUSE
BOUVIGNY
LA VIGNE
BAILLY-BAILLEUL
BERNAY
HARFLEUR
DONNEMOURS
VILLERS COTTERETS
SUIPPES
LA CHAPELLE D'ANGOU
VERNOU
ST HILAIRE LES ANDRESIS
ERBRAY
PERRIERS
NEUVY-BOURGUEIL
LA CHAISE
ST AFRIQUE
ST PHOSLAND
LA VILHAIN
COUZE-ST CROIX
SOYEUX
AIX D'ANS
MEXIMIEUX
ST PILAT
GRENOBLE
ST VENTURE
GRANDE RIVOLI
LA LOUBE


CHERBOURG
LE HAVRE
ROUEN
CAEN
PARIS
MÉZIERES
VERDUN
METZ
HAUTVILLERS
NANCY
ÉPINAL
RENNES
LE MANS
AUXERRE
NANTES
BOURGES
DIJON
BESANÇ
MELLE
SAVOIE
JURA

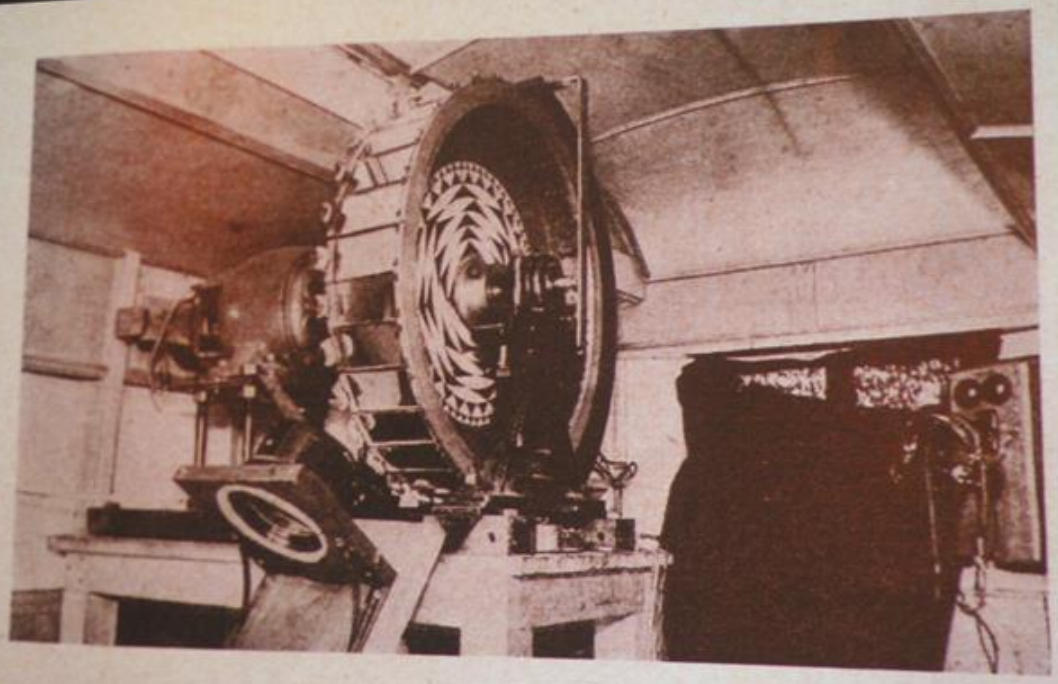


FIG. 206. — Tambour à miroirs de grand diamètre utilisé en Angleterre

Color TV's Alphabet Soup

- Or, how NTSC Begat SECAM, PAL and Their Descendants

John Pinckney

2008 Early Television Convention
Hilliard, Ohio U.S.A.


cox


COX

IN THE BEGINNING...

CBS FIELD SEQUENTIAL

1949-1952 FCC TESTS AND STANDARD

Horizontal Resolution:	405 lines
Horizontal Sweep	29.160 MHz
Fields	144
Frames	72
Color Fields	48
Color Frames	24

NTSC	NTSC-M	*NTSC-A*	*NTSC-I*
Lines/Fields	525/60	405/50	625/50
Horizontal Sweep	15.734 kHz	10.125 kHz	15.625 kHz
Vertical Sweep	60 Hz	50Hz	50Hz
Color Burst Frequency	3.5795459 MHz	2.6578125 MHz	4.4296875 MHz
Video Bandwidth	4.2 MHz	3.2 MHz*???*	
Audio Carrier	4.5 MHz	-.75MHz*???*	

NTSC-J is identical to NTSC-M except black level and blanking levels are identical at 0 IRE


BBC
COLOUR
TELEVISION
BBC

SECAM	SECAM B,G,H	SECAM D,K,K1,L
Lines/Fields	625/50	625/50
Horizontal Frequency	15.625 kHz	15.625 kHz
Vertical Frequency	50 Hz	50 Hz
Video Bandwidth	5.0 MHz	6.0 MHz
Sound Carrier	5.5 MHz	6.5 MHz

PAL	PAL	PAL N	PAL M
Lines/Fields	625/50	625/50	525/60
Horizontal Sweep	15.625 kHz	15.625 kHz	15.750 kHz
Vertical Sweep	50 Hz	50 Hz	60 Hz
Color Subcarrier	4.433618 MHz	3.582056 MHz	3.575611 MHz
Video Bandwidth	5.0 MHz	4.2 MHz	4.2 MHz
Audio Carrier	5.5 MHz	4.5 MHz	4.5 MHz

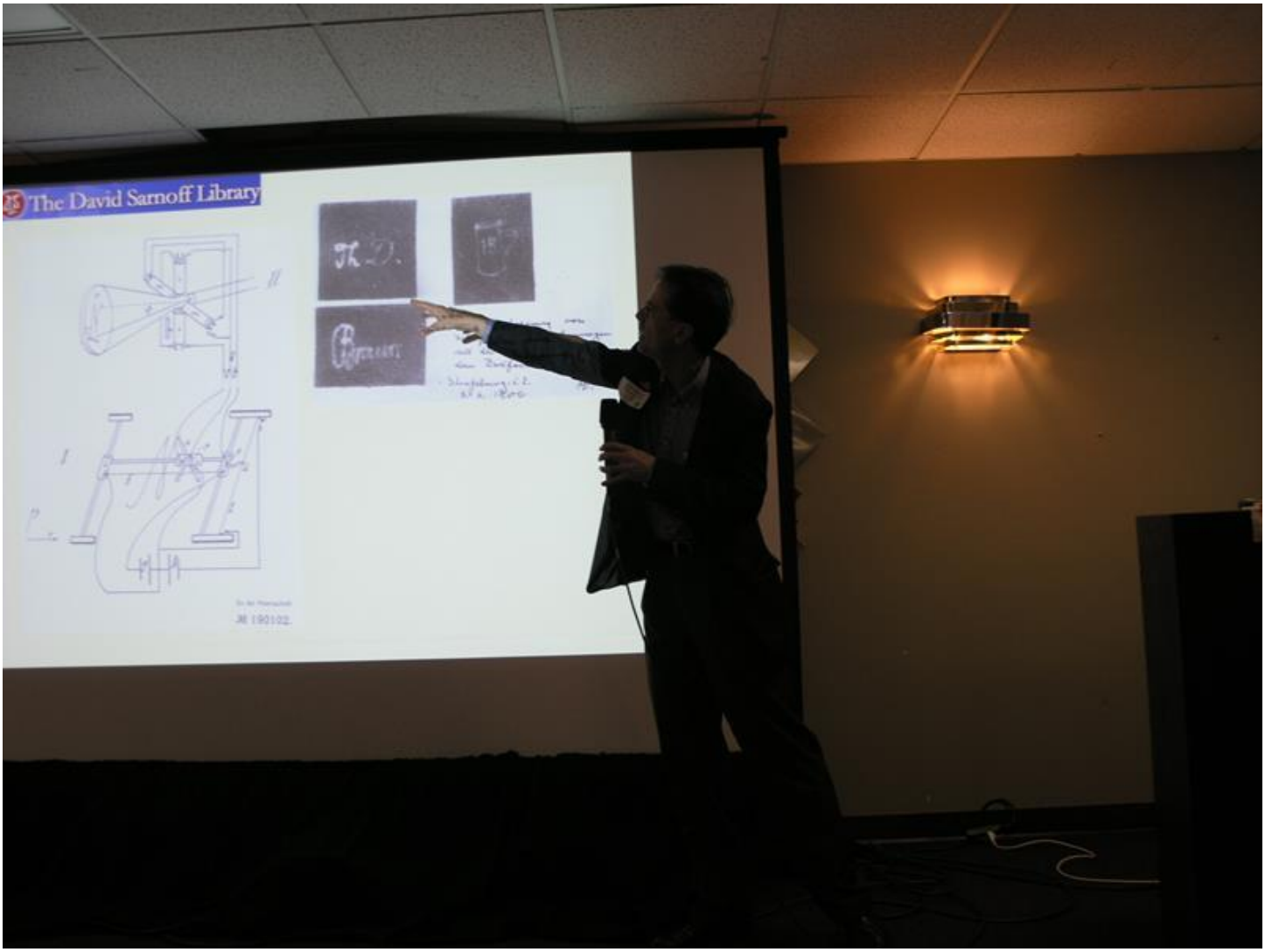

Alex Magoun
Princeton, NJ
48

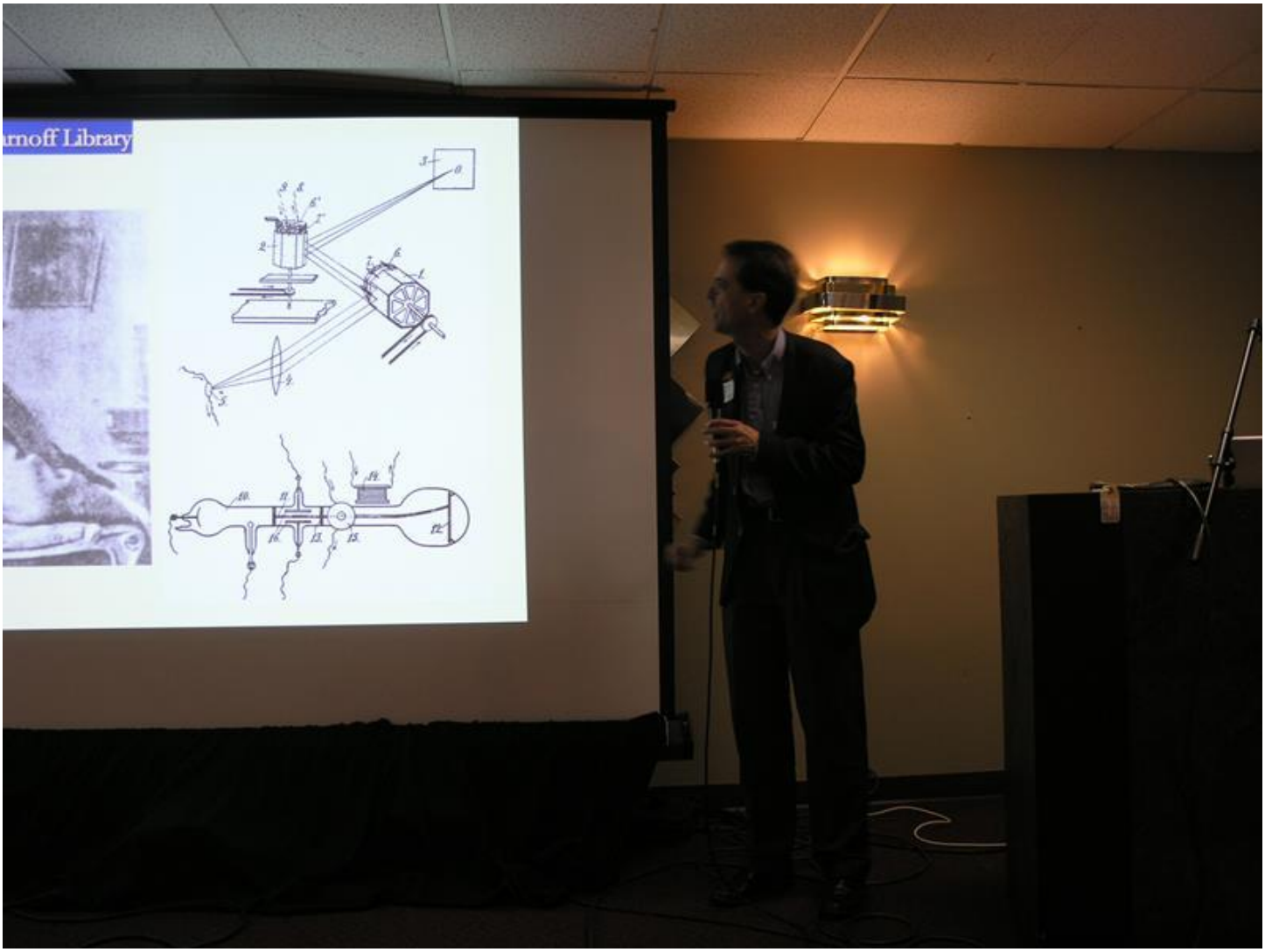

Alex Magoun
Princeton, NJ
40

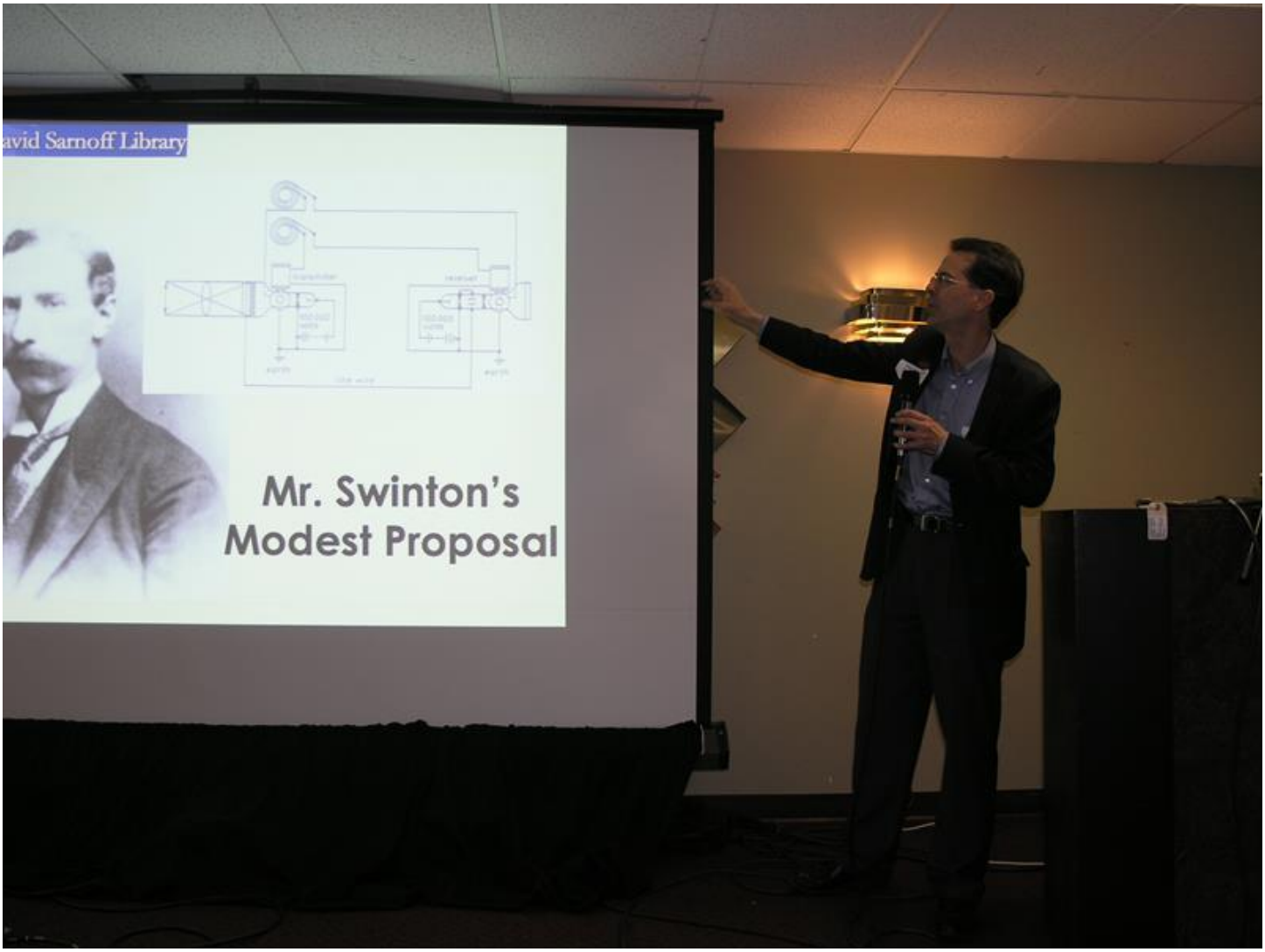
The David Sarnoff Library

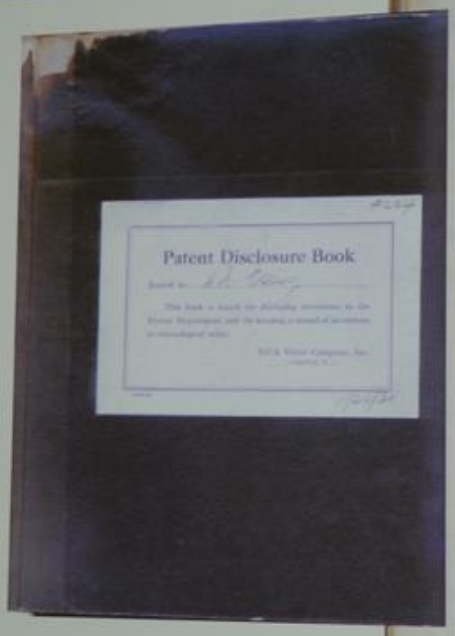
Conception

He Started It


The David Sarnoff Library


rnoff Library


avid Sarnoff Library
Mr. Swinton's
Modest Proposal



4

DISCLOSURE TO PATENT DEPARTMENT

METHODS OF MOSAIC CATHODE CONSTRUCTION

(ATTENTION OF MR. Rathbun)

In the present transmitting tube, a mosaic cathode is required, the same consisting of a large number of small particles of silver insulated from each other, these being in turn sensitized with Cesium by the usual method.

Following are the methods of producing these mosaic cathodes:-

1. Coat the supporting insulating material with a continuous film of metallic silver.
   (A) Divide same into separate parts by mechanical means.
   (B) Or by non-mechanical means.

2. Apply the separate spots directly to the supporting insulating material.

3. Apply silver compound in separate spots directly to the insulating material. Change into metallic silver.

4. May be produced by heating with compound such as silver carbonate or oxide, reducing same by heating. It may be obtained by chemical deposition (such as Wehner's process) by evaporation in a vacuum from a molten bead of silver, or sputtering in a partial vacuum. The film about be produced by spraying with metallic silver (Schoop process).

   (A) This is heated in disclosure by R. Ives.
   (B) By heating a silver film of correct thickness at the correct temperature, the same may be caused to "draw" up into droplets.

5. The spots may be applied directly avoiding separation by mechanical means by evaporating, sputtering or spraying thru a mask. The separate silver particles might be applied to or in some binder which would support them.

6. Silver compound can be applied by any of the common means such as spraying, dusting, brushing, flowing, printing onto the supporting medium with or without use of ~~[illegible]~~ binder. If a thin film of oxide or carbonate is applied to a supporting medium can also by flowing or better spraying, a suspension of the same in a binder, drying then heating the reduced silver will form in small droplets which experiment shows to be very satisfactory in producing a mosaic screen.

OXIDATION OF MOSAIC CATHODES BY
HIGH FREQUENCY DISCHARGE

In the process of sensitizing the silver mosaic

Inventor — Date 12/1/31

Witness — Date of Conception 11/10/31

Original for Patents Dept. Copy
Duplicate for Inventor's Record

DISCLOSURE TO PATENT DEPARTMENT

METHODS OF MOSAIC CATHODE CONSTRUCTION

(ATTENTION OF MR. Gallatzenstein.)

In the present transmitting tube, a mosaic cathode is required, the same consisting of a large number of small particles of silver insulated from each other, these being in turn sensitized with Cesium by the usual method.

Following are the methods of producing these mosaic cathodes:-

1. Coat the supporting insulating material with a continuous film of metallic silver.
   (a) Divide same into separate parts by mechanical means.
   (b) Or by non-mechanical means.

2. Apply the separate spots directly to the supporting insulating material.

3. Apply silver compound in separate spots directly to the insulating material. Change into metallic silver.

4. May be produced by coating with compound such as silver carbonate or oxide, reducing same by heating. It may be obtained by chemical Deposition (such as Mannes's process) by evaporation in a vacuum from a molten head of silver, or sputtering in a partial vacuum. The film about to produced by spraying with metallic silver (Schoop process).

   (A) This is tested in disclosure by H. Isaac.
   (B) by heating a silver film of correct thickness at the correct temperature, the same may be caused to "break" up into droplets.

5. The spots may be applied directly avoiding separation by mechanical means by evaporation, sputtering or spraying thru a mask. The separate silver particles might be applied to or in some binder which would support them.

6. Silver compound can be applied by any of the common means such as spraying, dusting, brushing, flowing, printing onto the supporting medium with or without use of ~~[illegible]~~ If a thin film of oxide or carbonate is applied to a supporting medium say mica by flowing or better spraying, a suspension of the same in a binder, drying thus heating the reduced silver will form to small droplets which experiment shows to be very satisfactory in producing a mosaic screen.

DERIVATION OF MOSAIC CATHODES BY HIGH FREQUENCY DISCHARGE

In the process of sensitizing the silver mosaic

12/1/31
Date

8/22/31
Date of Conception

Witness

Original for Patent Dept. Office
Duplicate for Inventor's Record

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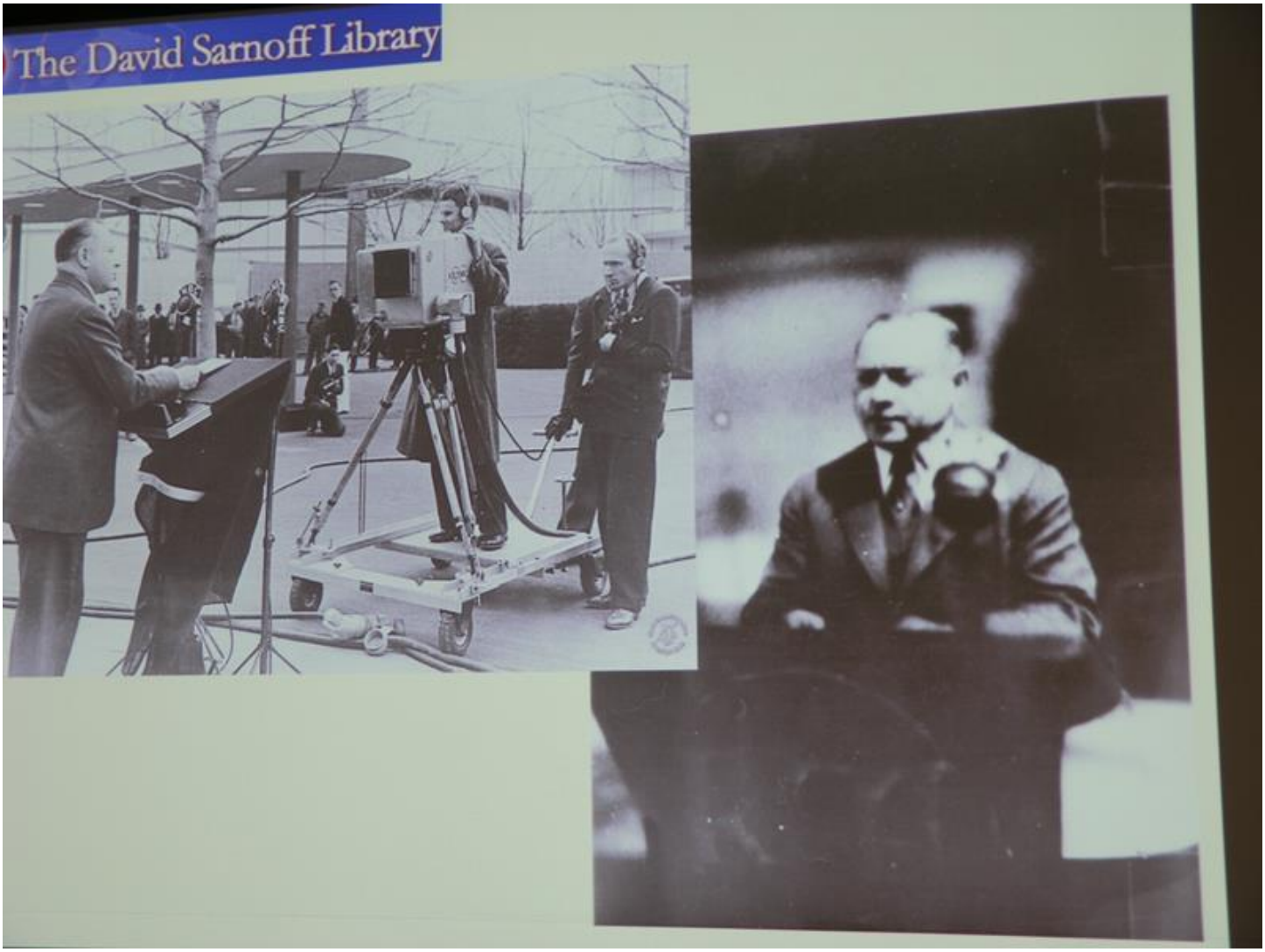
School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RCA-NBC TELEVISION TALENT
HELD HERE EVRY SUNDAY. 3 TO
FOR TRYOUT AT INFORMATION BOOTH IN RCA EXH

CBS PIONEERS FULL COLOR FINE-SCREEN TELEVISION!

This is the approximate quality of the new CBS postwar television – fine-definition – in full and natural color.

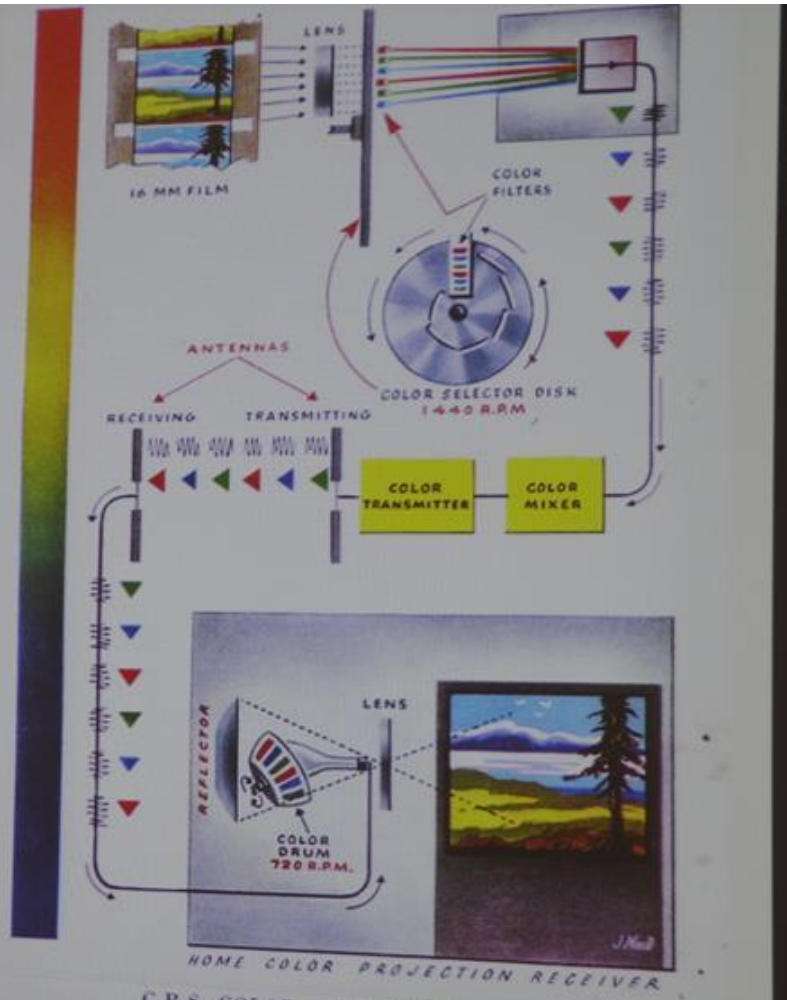
On October 30, 1945 the first experimental broadcast of full-color television television in the color frequencies was successfully achieved by CBS.

As nearly as the printer's press and inks can accomplish, the picture above reproduces the quality of the new CBS High-Definition Television on a section of a picture measuring in full 7½" x 10". Note the frame. Note the depth of definition – the warm patterns, lustrous play of lights.

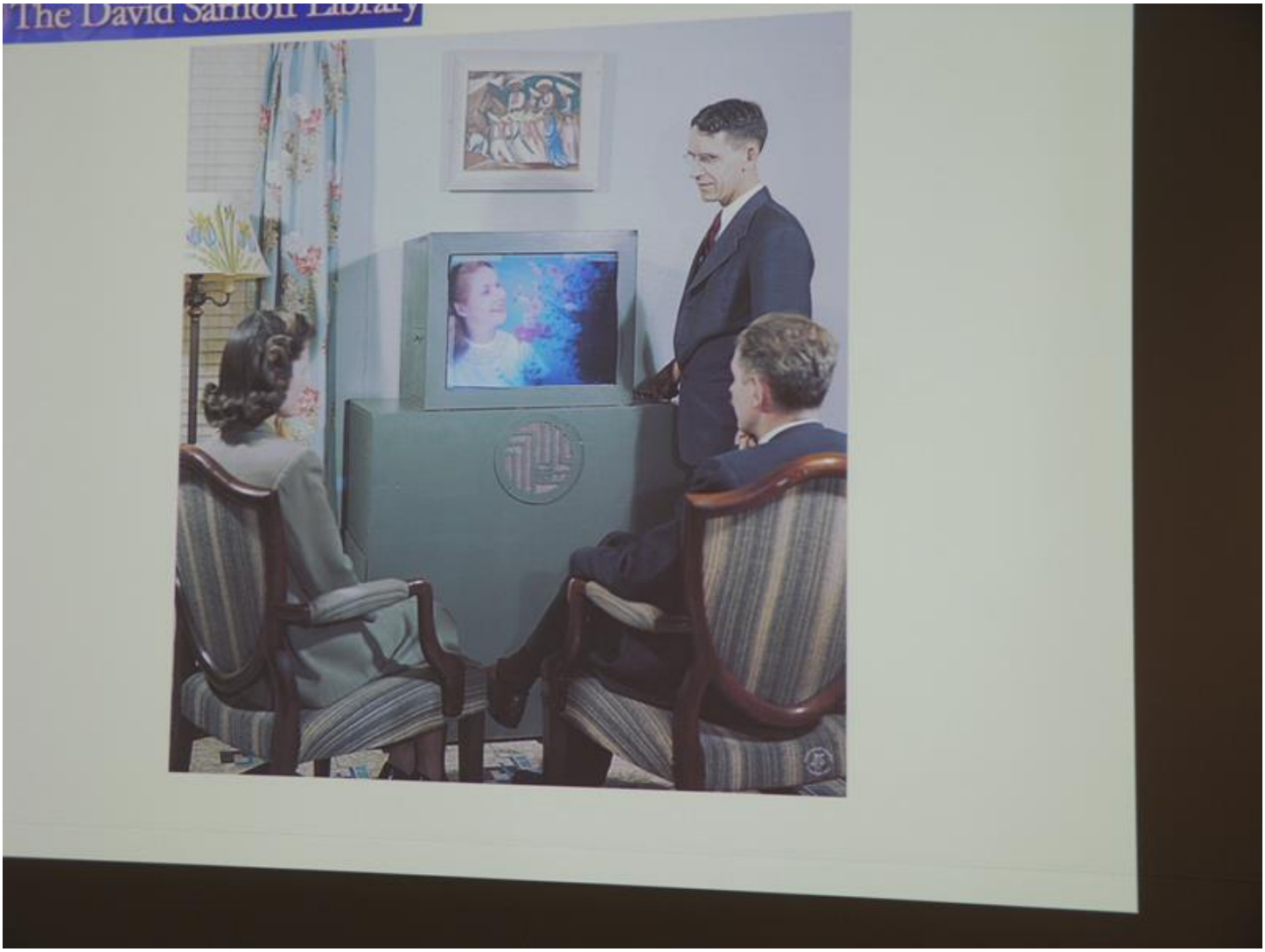
Thus the long search by CBS for pictures really great was just possible! Has passed perhaps the most important milestone in the new art. The event was certainly of first importance to everyone concerned with television.

Much remains to be done, much is being done, to put this new, brilliant form of television in your hands. You may be sure that CBS is doing all it possibly can.

THE COLUMBIA BROADCASTING SYSTEM



C.B.S. COLOR SYSTEM FOR FILM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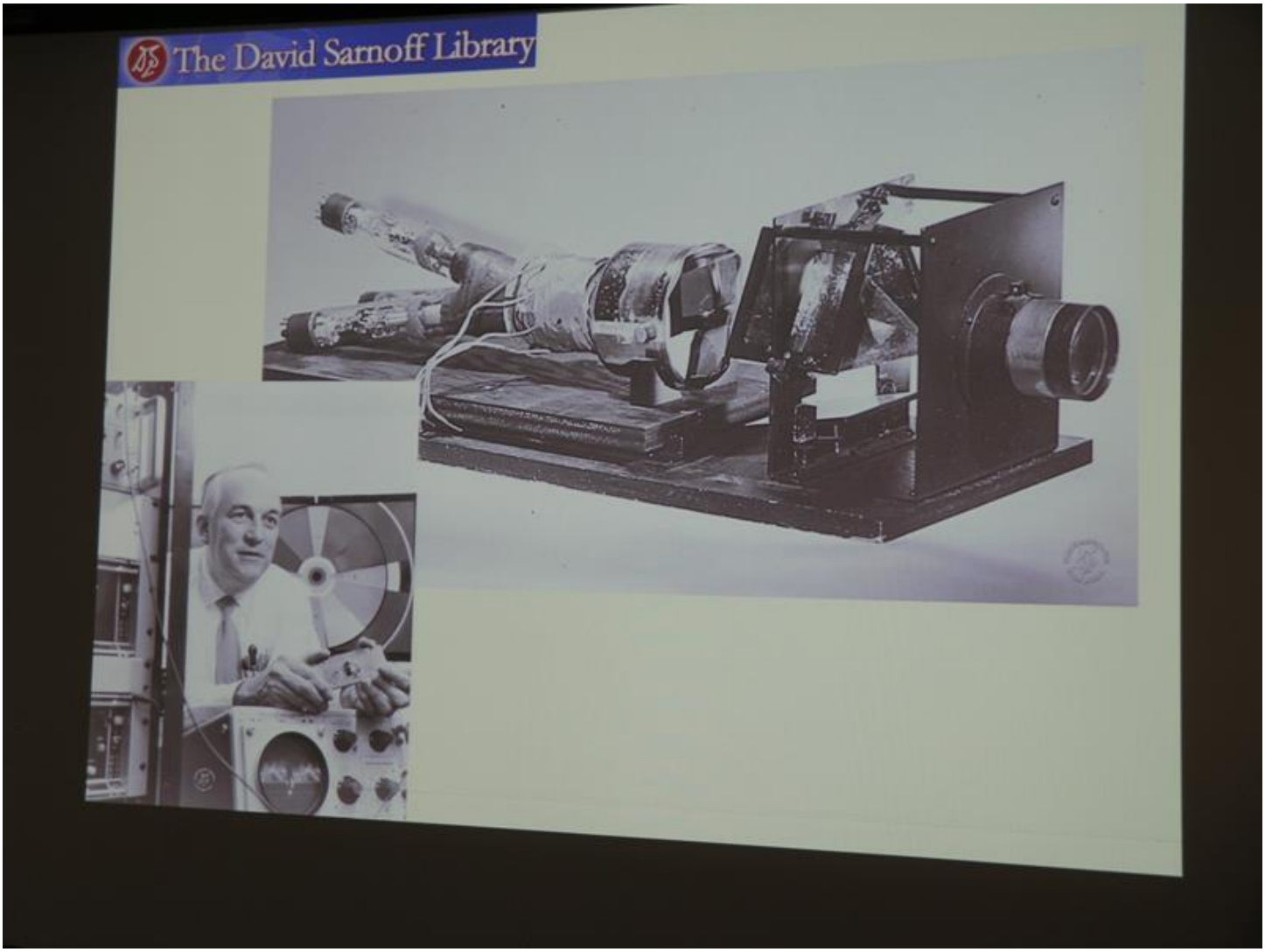
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RCA Production (1000s)

	B&W	COLOR	
1946	5	5	1954
1947	96	20	1955
1948	226	121	1956
1949	505	69	1957
1950	1065	47	1958
1951	734	85	1959
1952	730	109	1960
1953	946	141	1961
1954	1195	297	1962
1955	1507	376	1963
1956	1291	490	1964
1957	1159	807	1965
1958	808	1301	1966

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20 Years Later

1960	120
1961	147
1962	438
1963	747
1964	1404
1965	2694
1966	5012
1967	5563


The David Sarnoff Library
RCA
Studio II
Home TV Programmer
Owners
Manual
Installation

RCA

Studio II

Home TV Programmer

Owners Manual

Installation
Operation

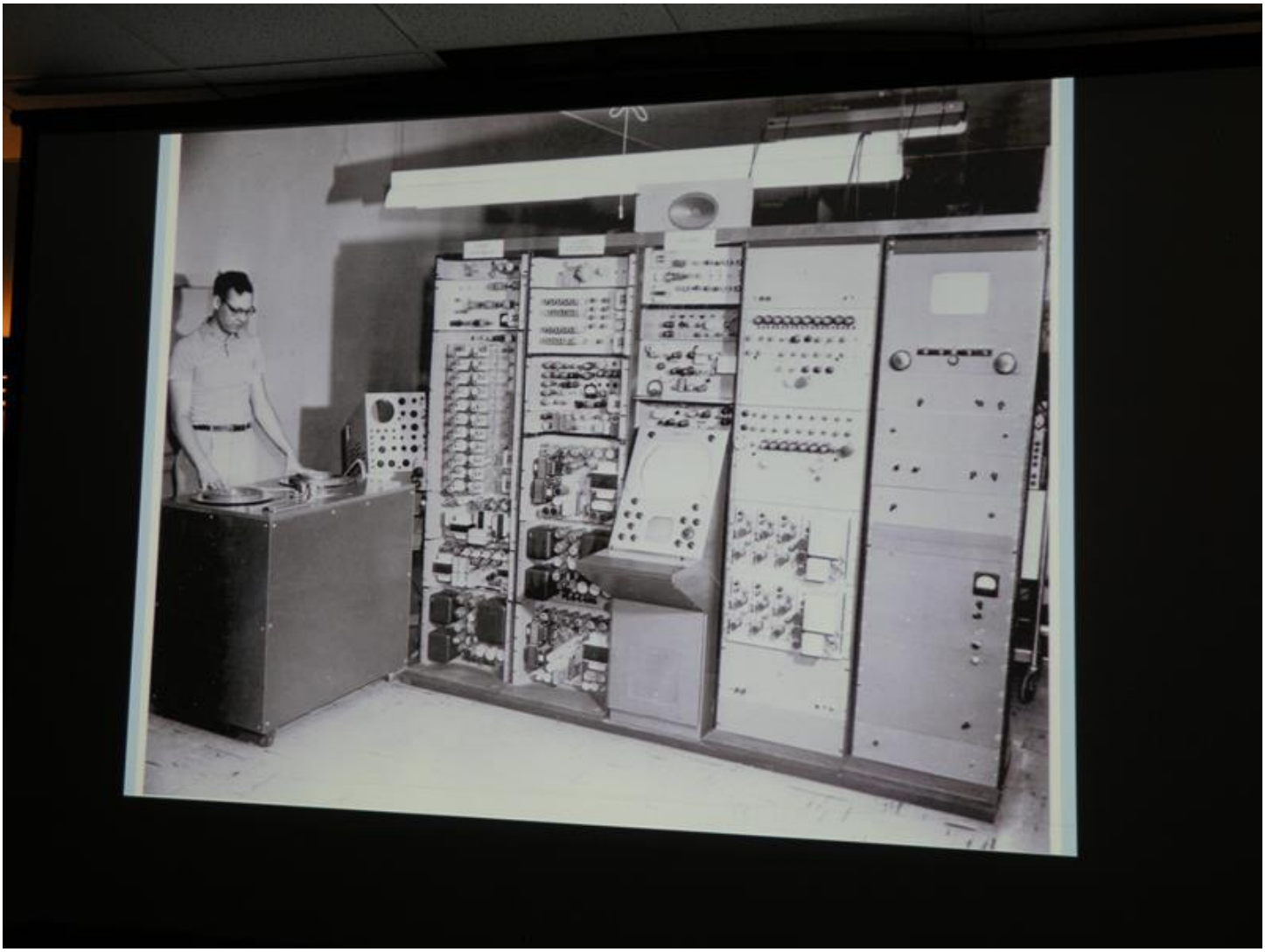

To You
from
Borden's

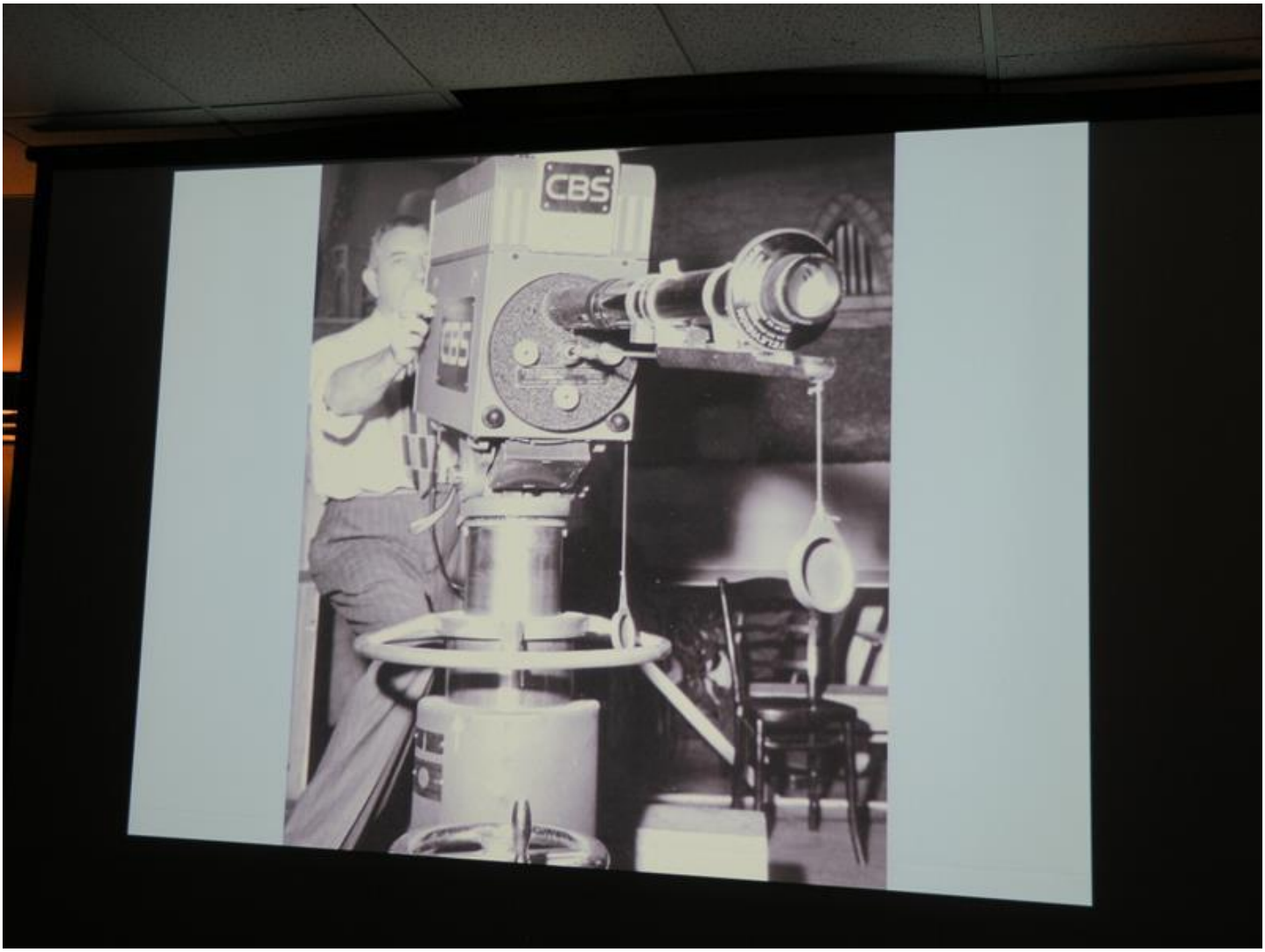

WNBT
NBC

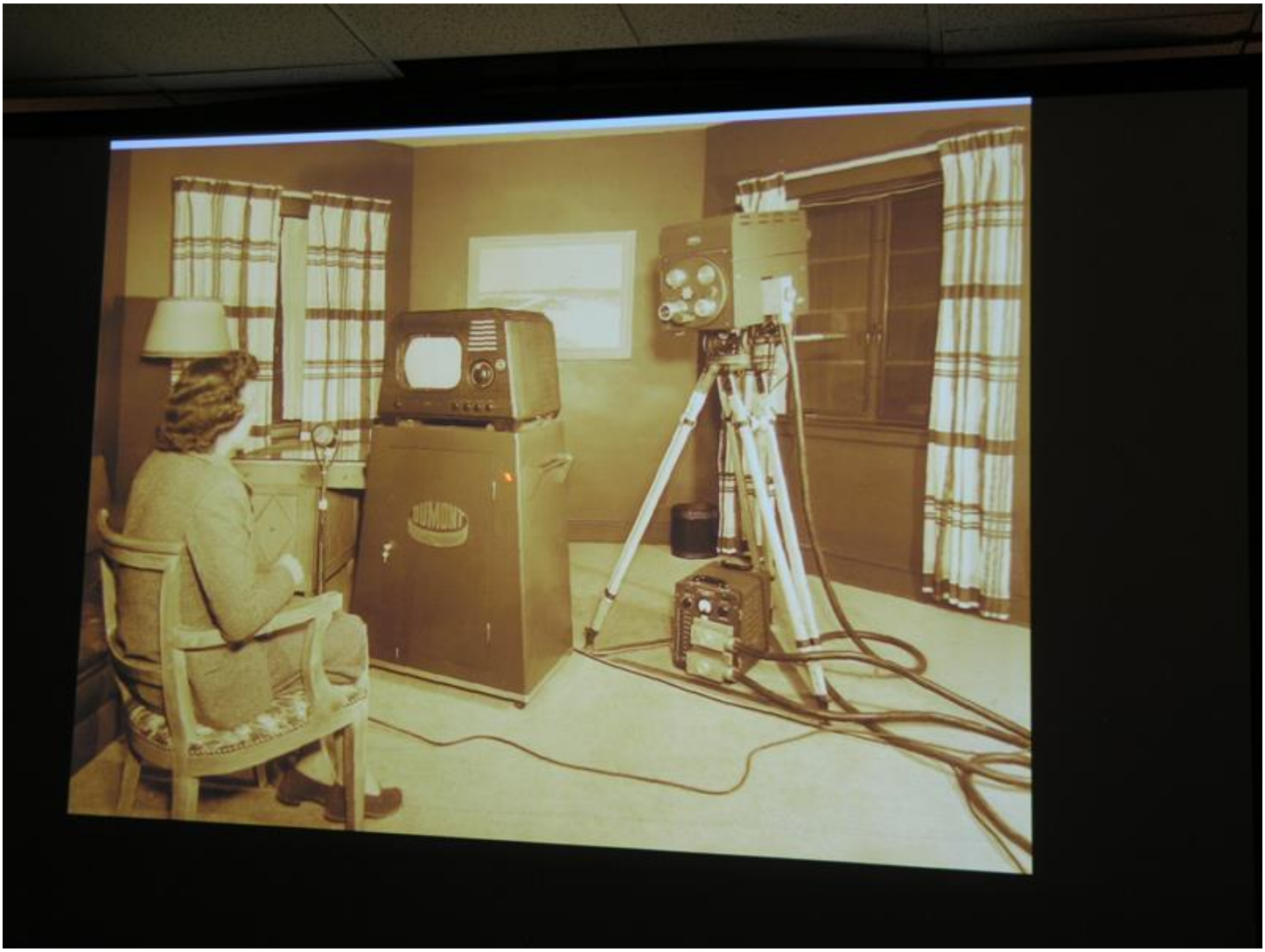

WNBT
NBC

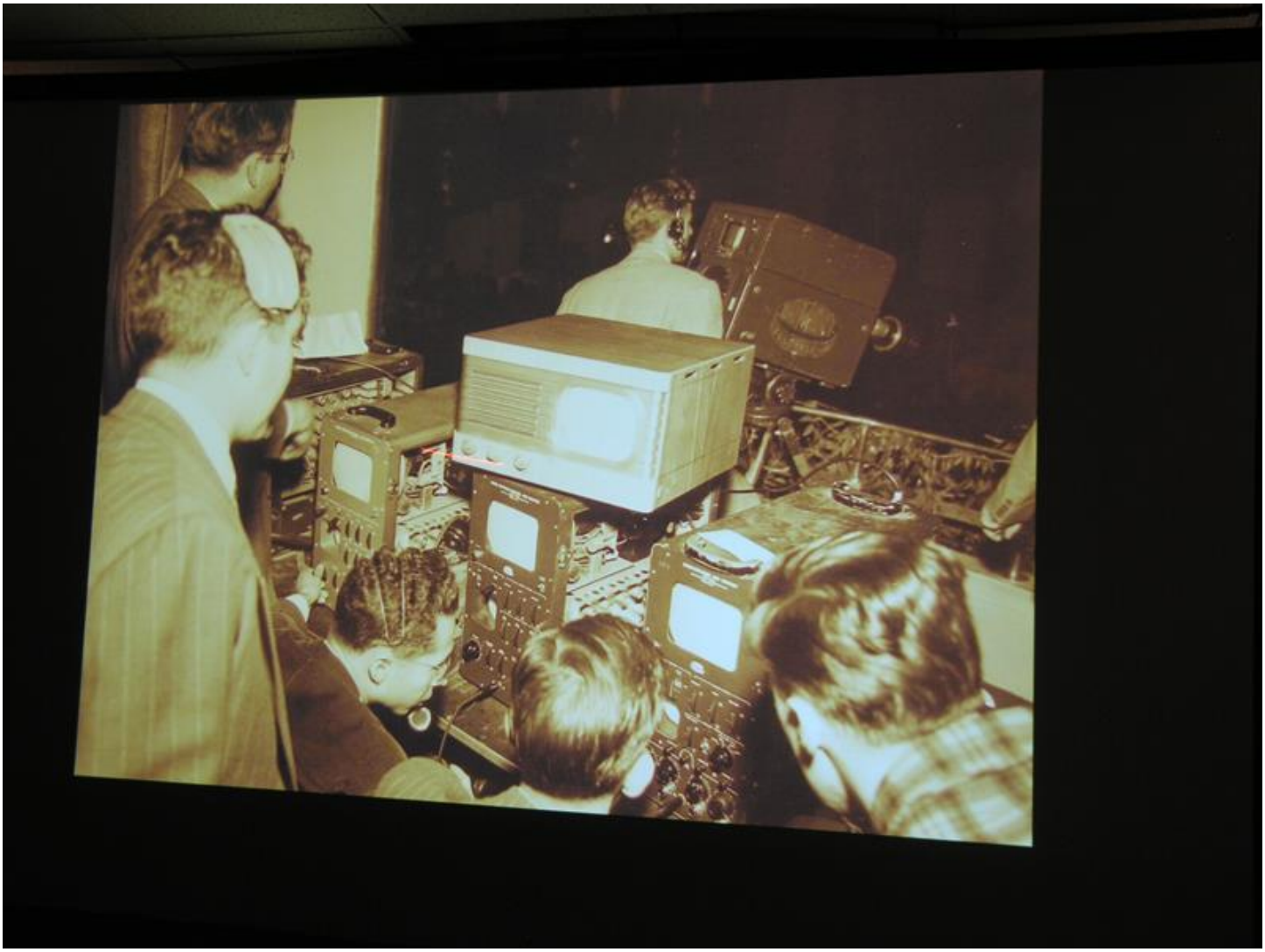

You'll whistle while you wash...
RINSO GETS OUT
DIRT

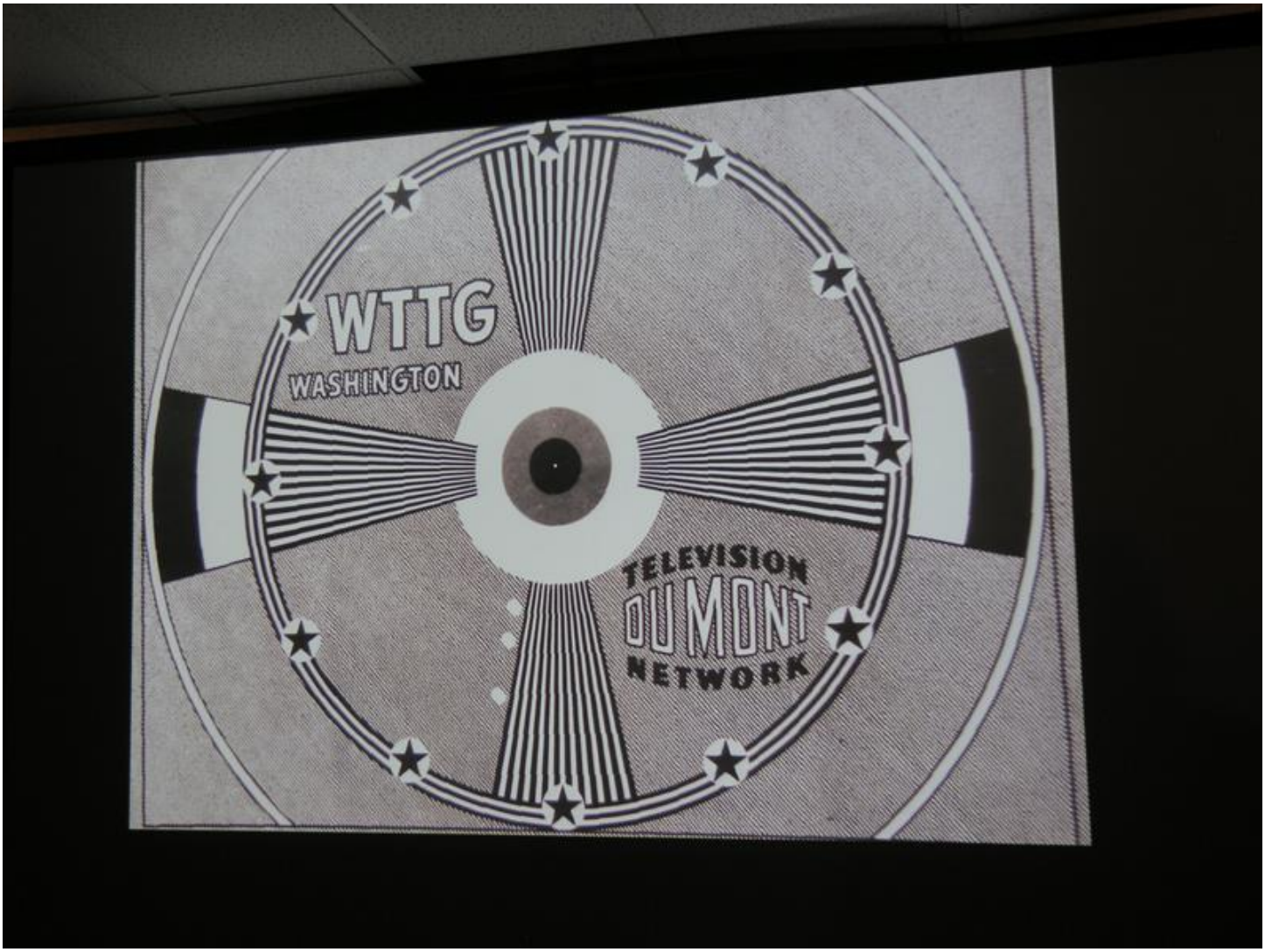

WNET
Television




CBS


DUMONT




WTTG
WASHINGTON
TELEVISION
DUMONT
NETWORK


CROSLEY
REDS


CROSLEY
REDS


1948 CROSLEY
MODEL: CC SERIAL #CC56945
CURB WEIGHT: 1403 LBS.
GAS TANK: 6.5 GALS
ENGINE: 44 CU. IN. 156 LBS.
26.5 HP AT 5400 RPM (ACTUAL) - 10 HP (AMA)
CROSLEY MOTORS
2532 SPRING GROVE AVE.
CINCINNATI 14, OHIO

Ruth Lyons

The Woman Who Created Talk TV

By Michael Banks

She was an up-front, real woman who rose from humble beginnings. Her daily live television show drew millions of viewers. She gave away cars. And her mere mention of a product could turn it into a household name.

This may sound like Oprah Winfrey, but it's a description of Ruth Lyons, a pioneering broadcaster whose audience in 1960 equaled that of Winfrey's today. With a mix of sentimentality and caustic commentary she ad-libbed her way through commercials and interviews with Hollywood stars. She ruled a broadcast empire and a famous charity all the while maintaining that she was simply a normal housewife and mother who happened to have a radio show. National magazines labeled her "The most influential housewife in America."

Her fame was such that throughout the 1950s and '60s, tens of thousands showed up for her remote broadcasts and other personal appearances. 100,000 people tried to get tickets for a 1957 event in her honor.

Ruth Lyons: The Woman Who Created Talk TV, is the first complete biography of this pioneering broadcaster and tough businesswoman. It includes her life story complete with fascinating events that even she didn't want the world to see. Follow Ruth through her days as a child growing up in Columbia Tusculum to her stretch on WLW up to the death of her daughter. Find out who she was and why she became the hardest working and most philanthropic in the business.

Written by Michael Banks, author of *Crosley: Two Brothers and a Business Empire That Transformed the Nation.*

Ruth Lyons
ISBN 978-1933197-494
Hardcover
$24.95
300 pages
7 x 10

Available in October.

"She was such a brilliant woman. I don't think I ever met anybody in broadcasting who had the integrity that she had." —Peter Nero

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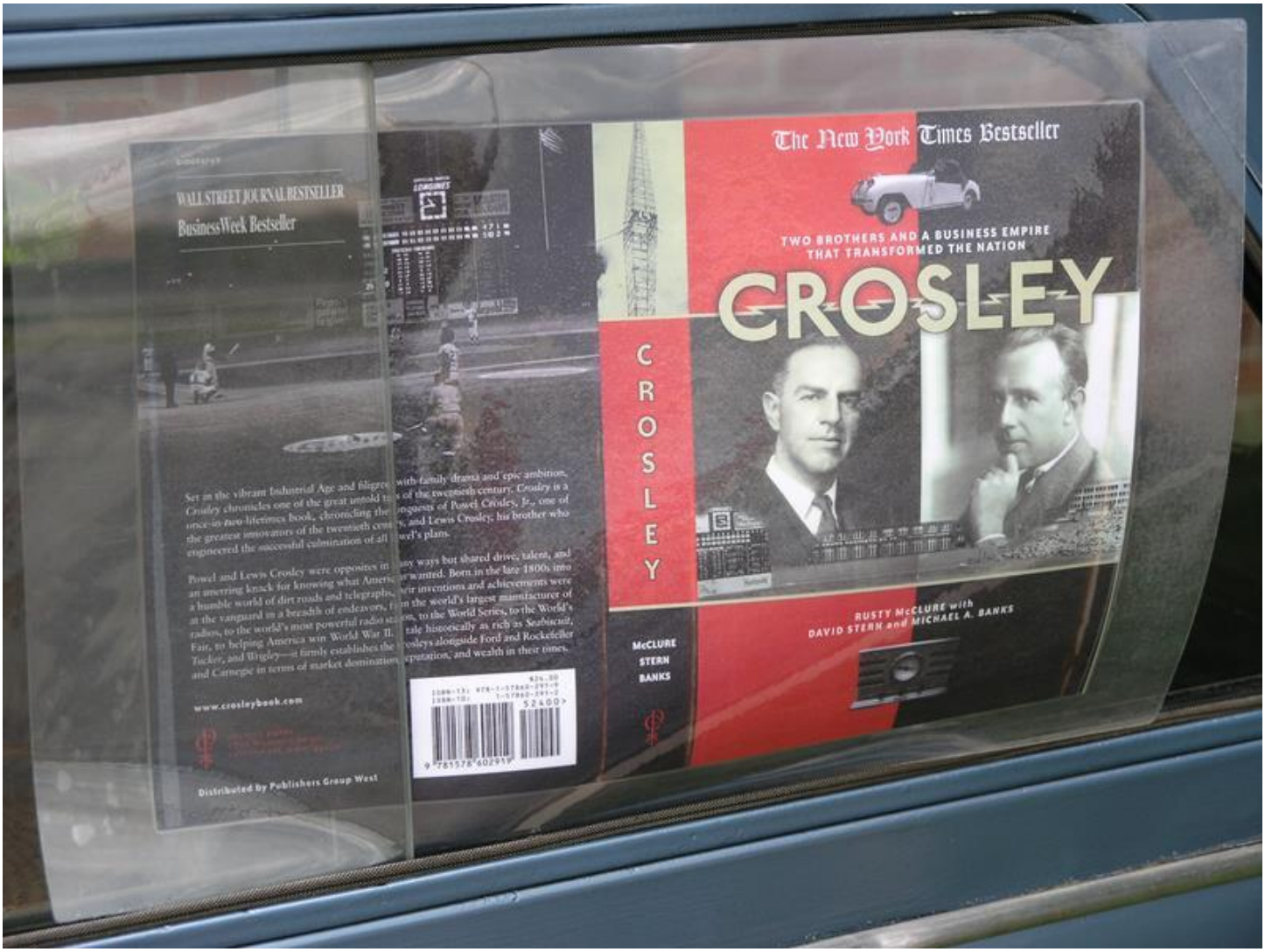
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RUSTY McCLURE with DAVID STERN and MICHAEL A. BANKS
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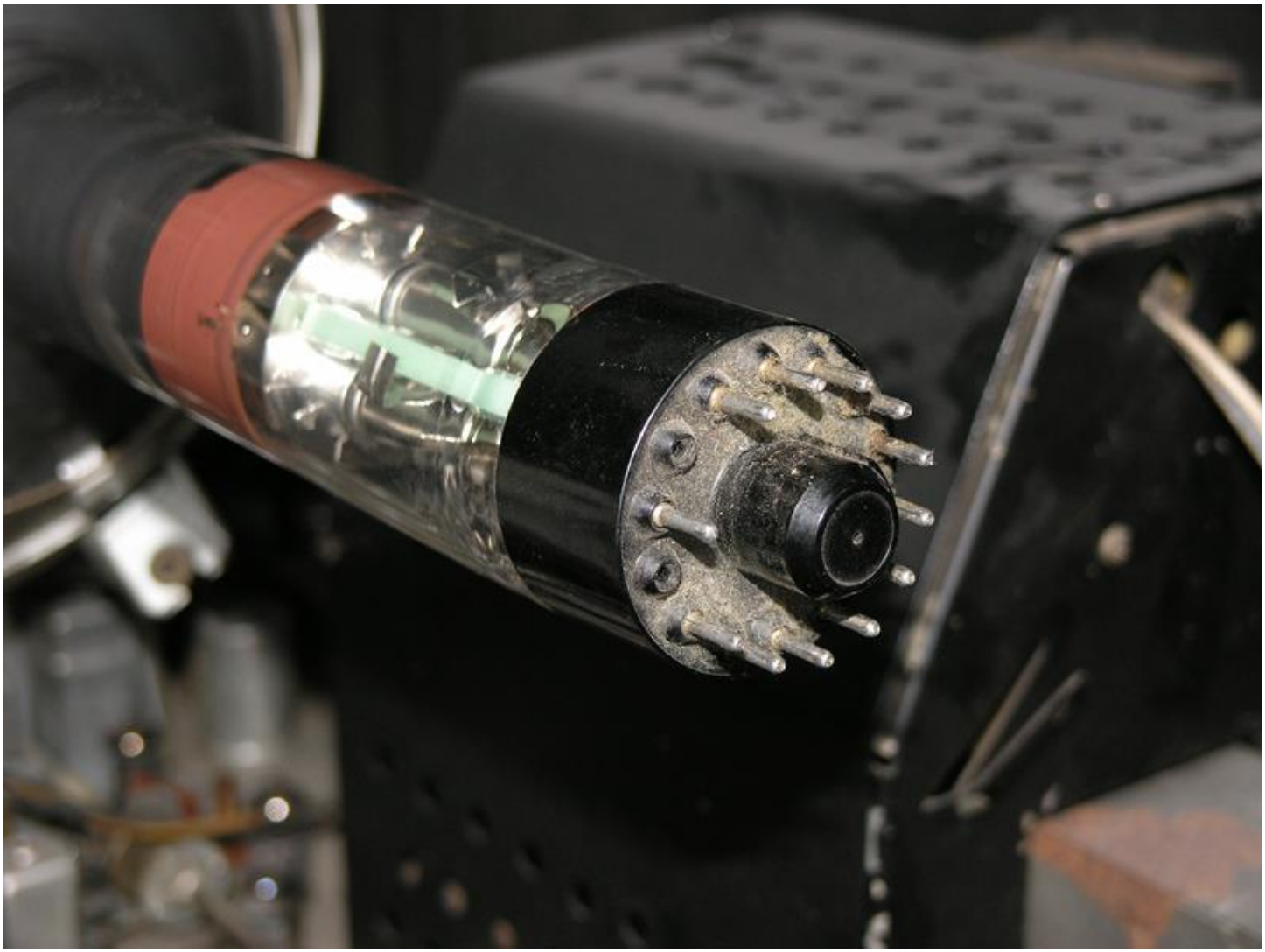

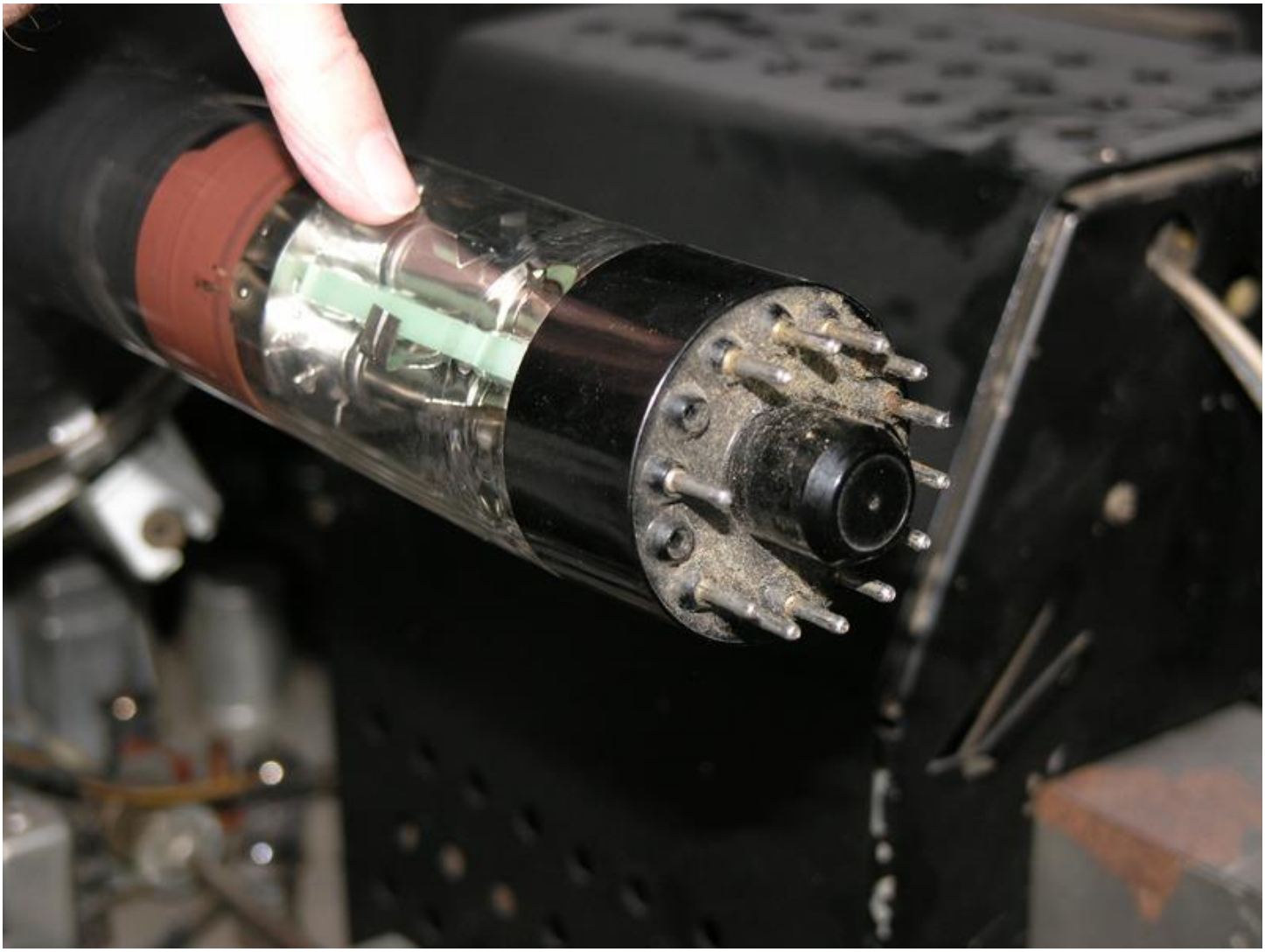

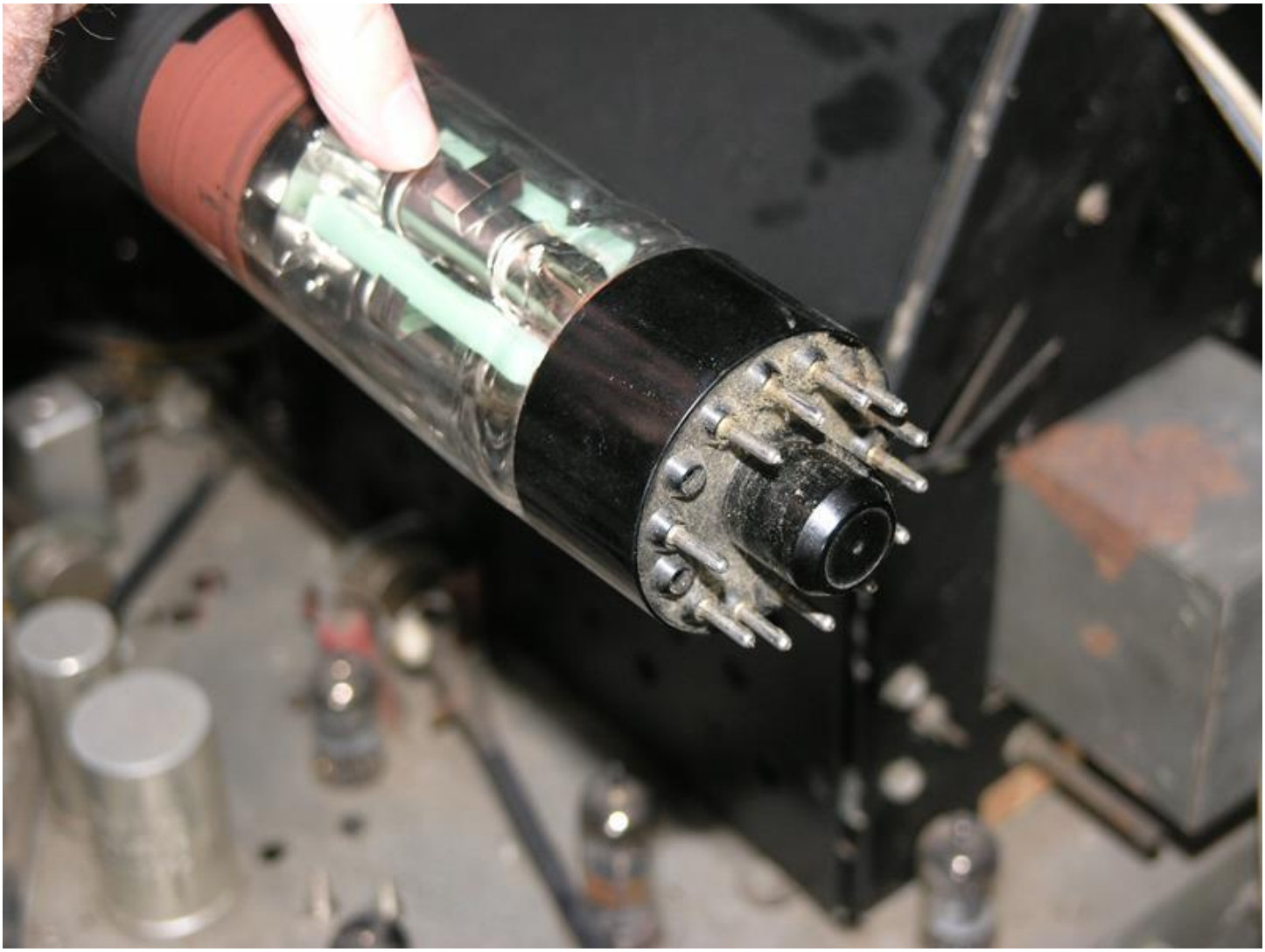

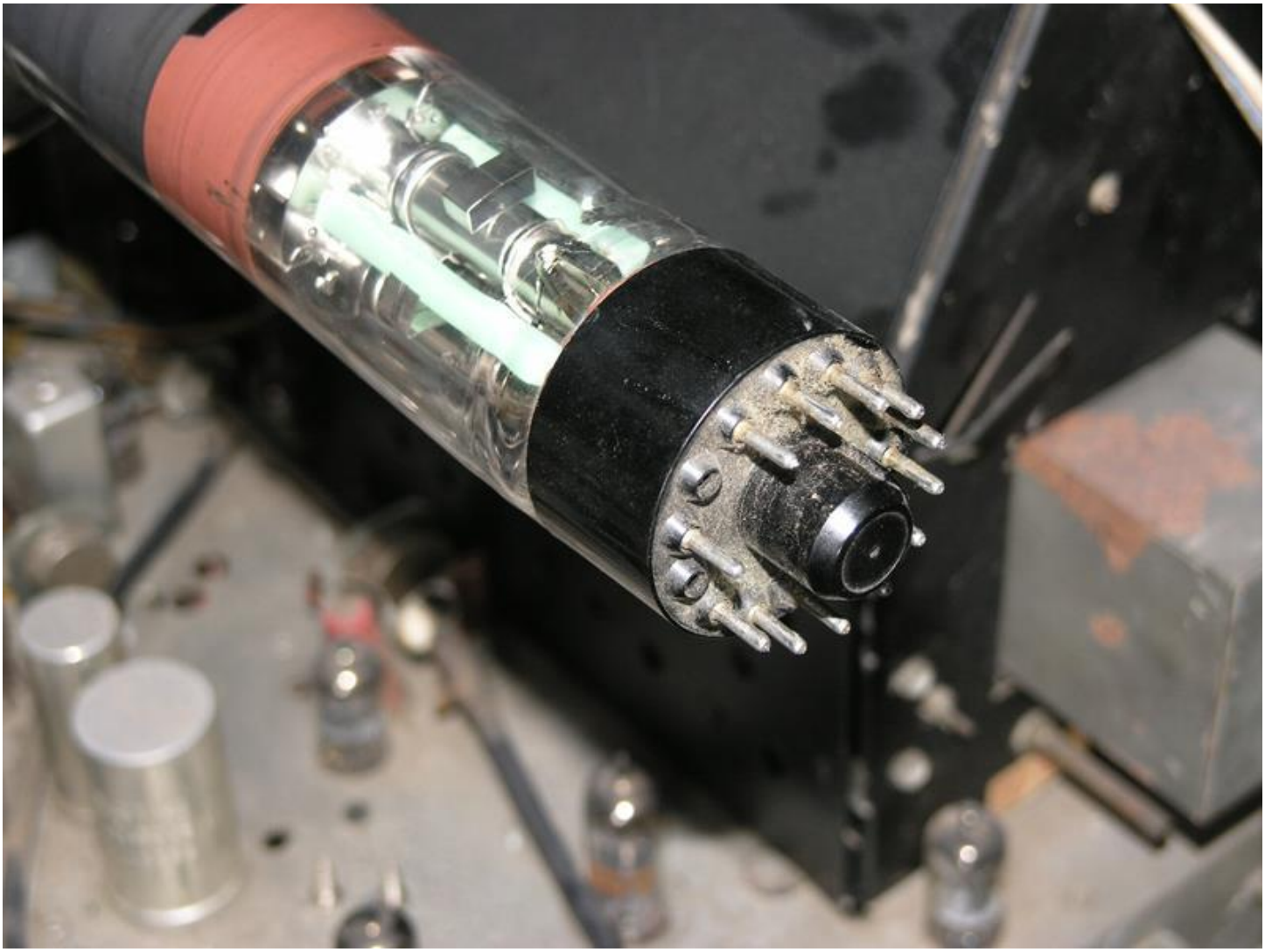

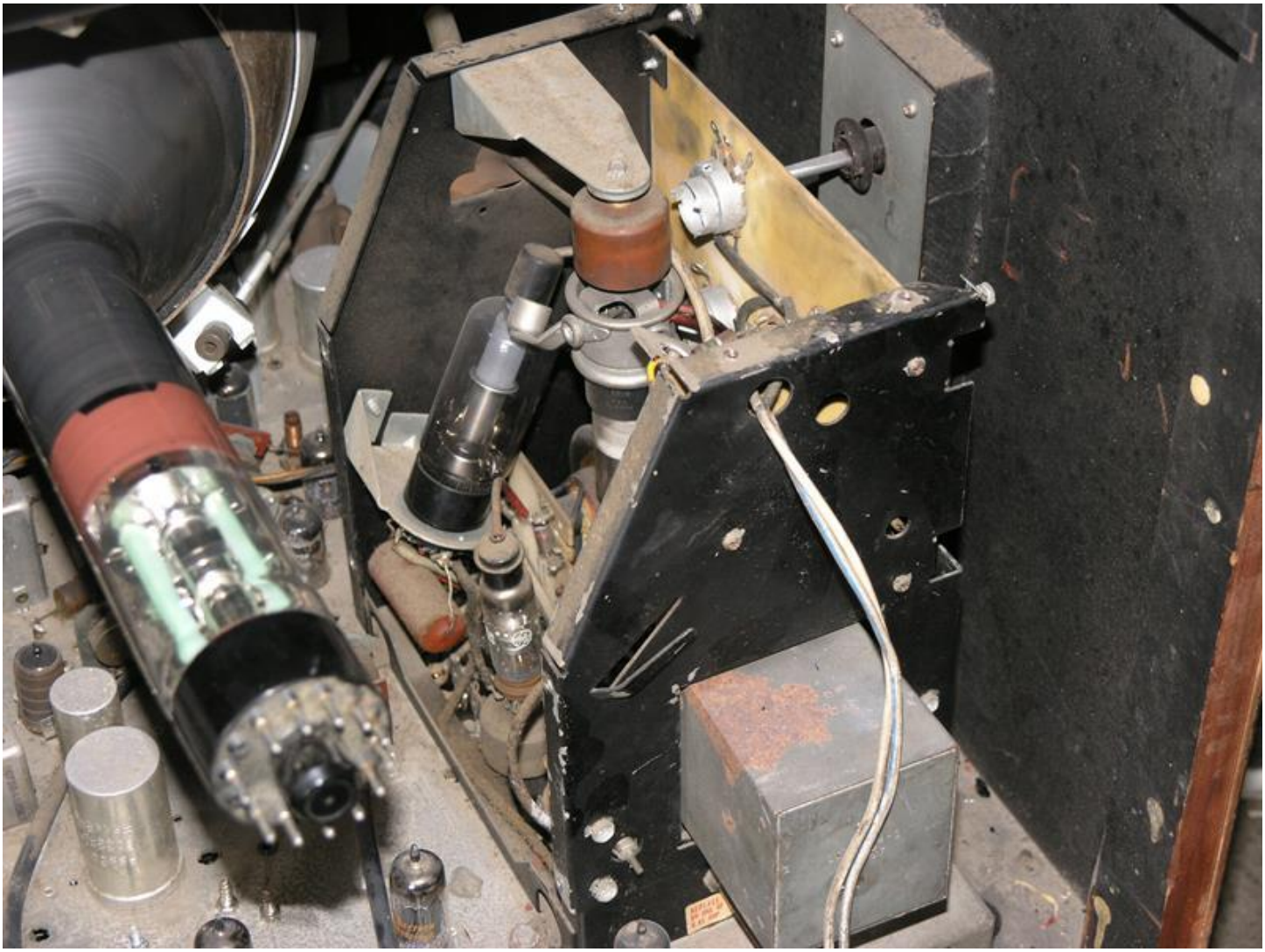

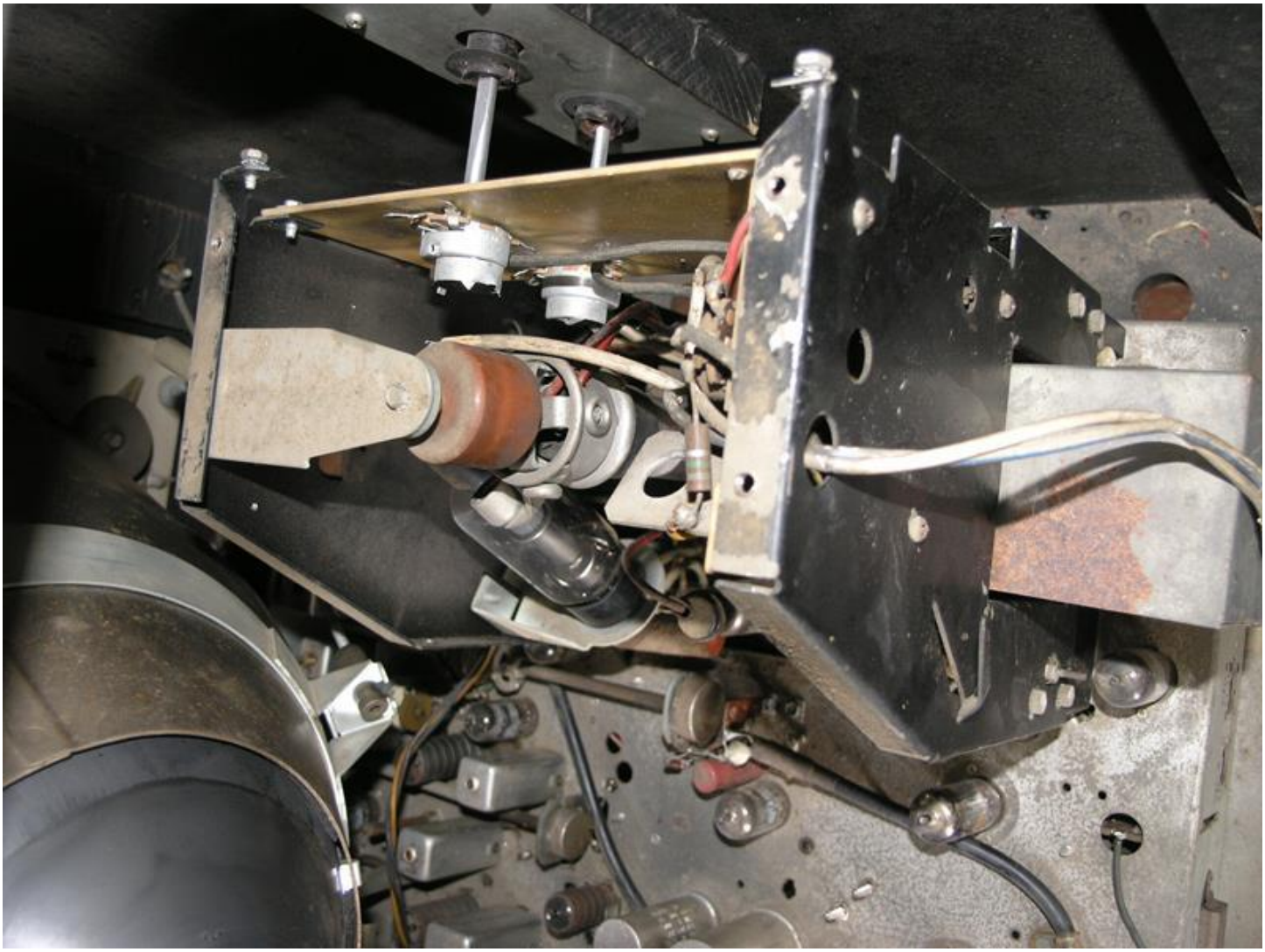

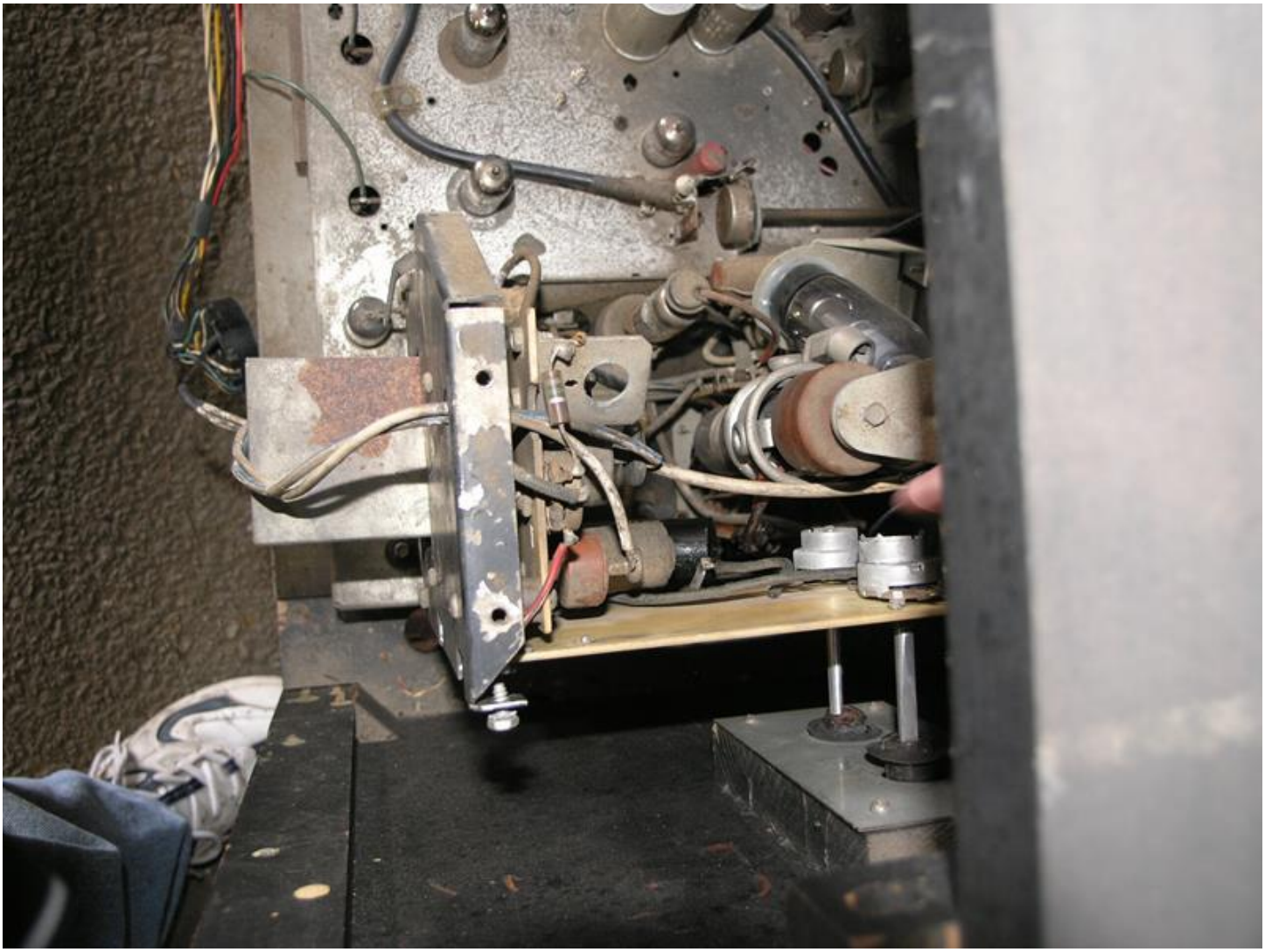

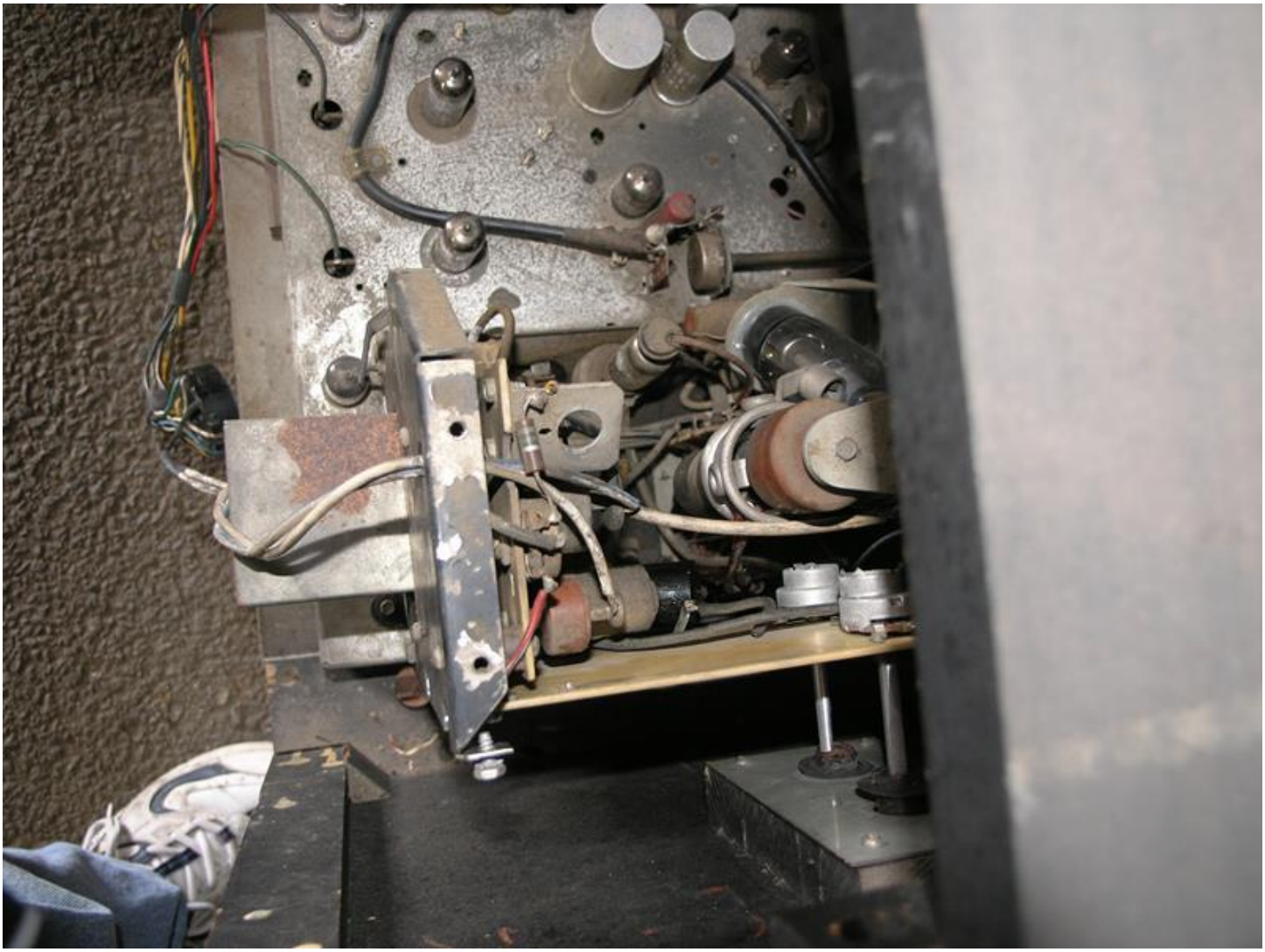

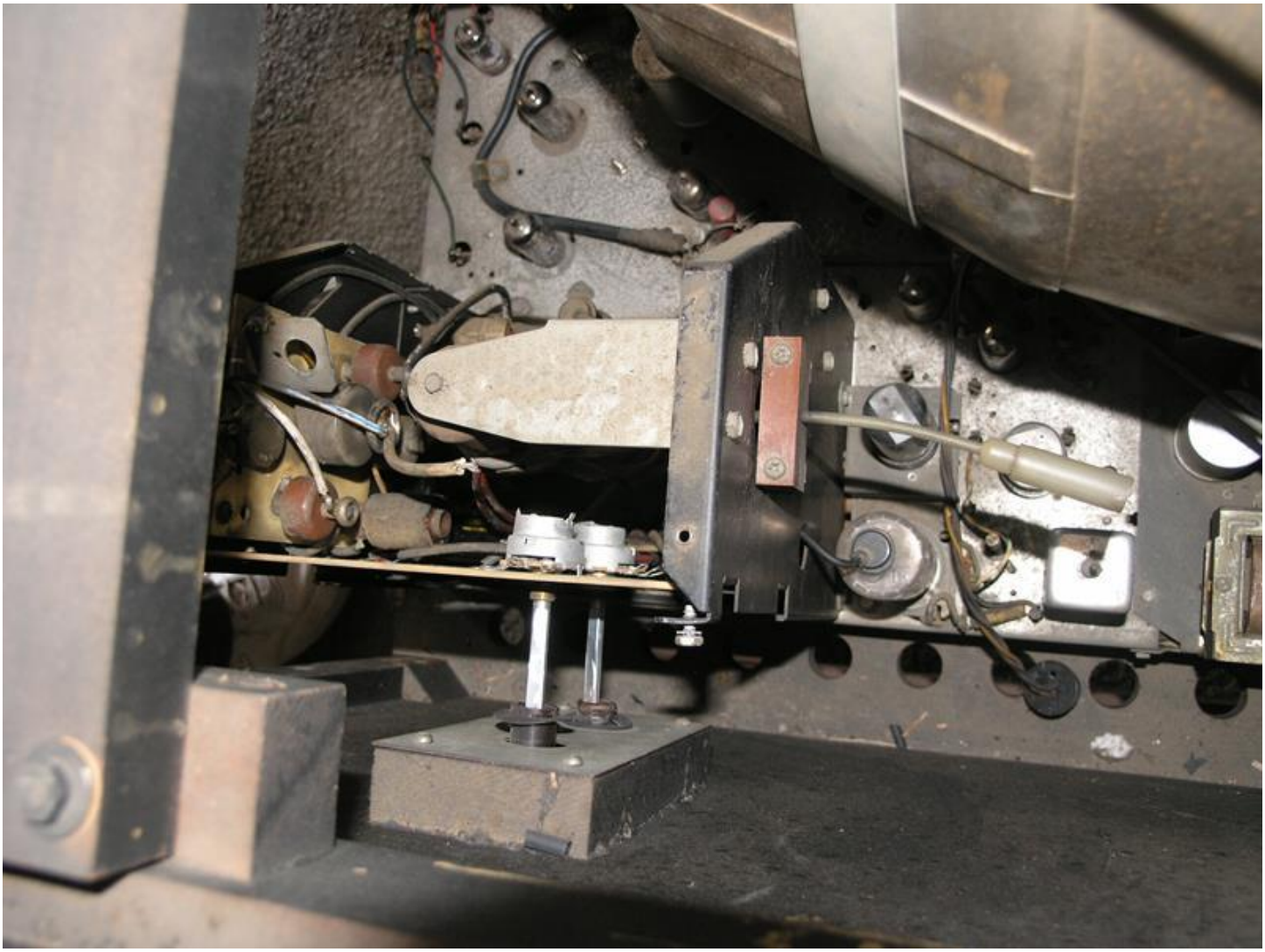

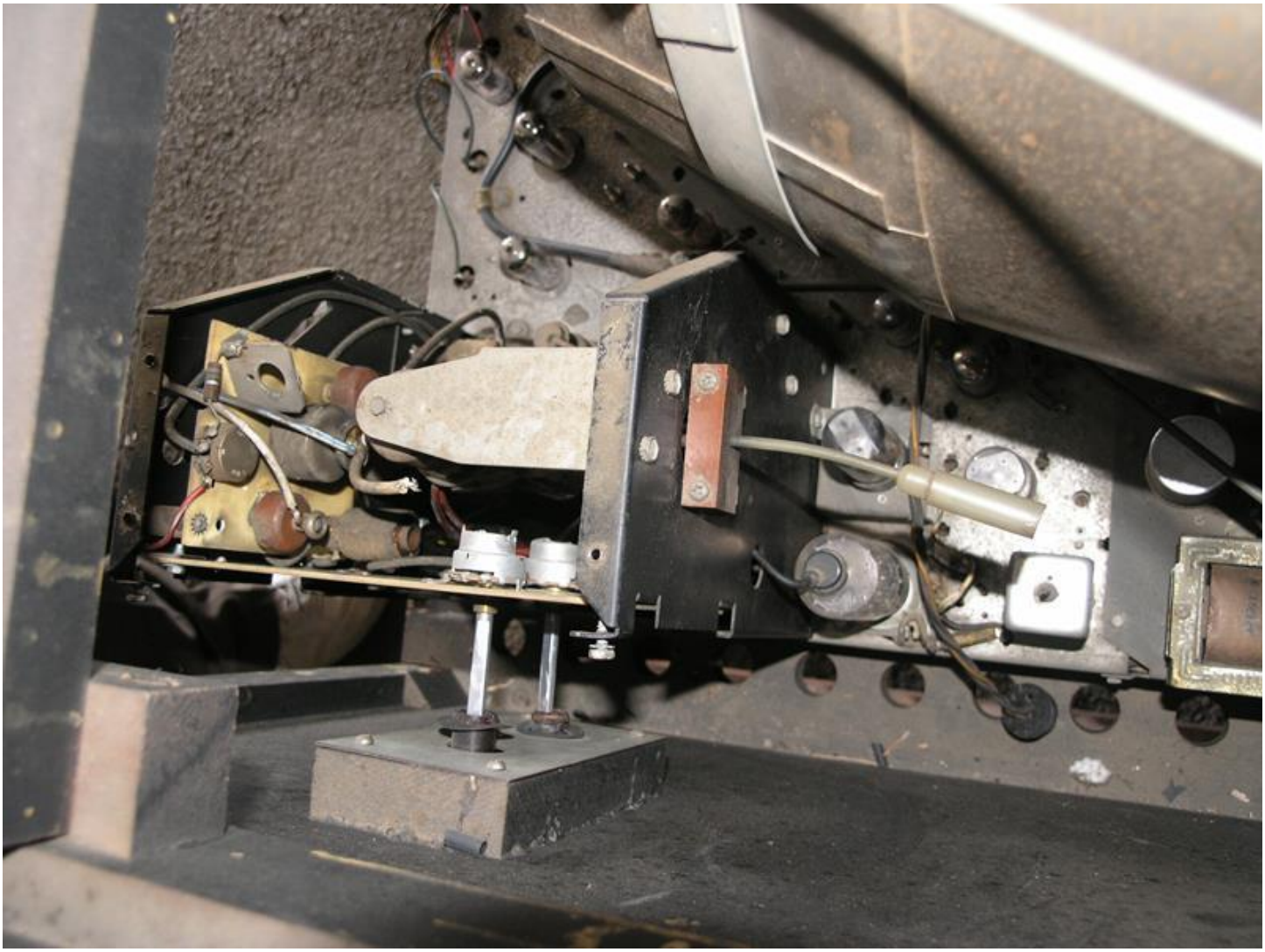

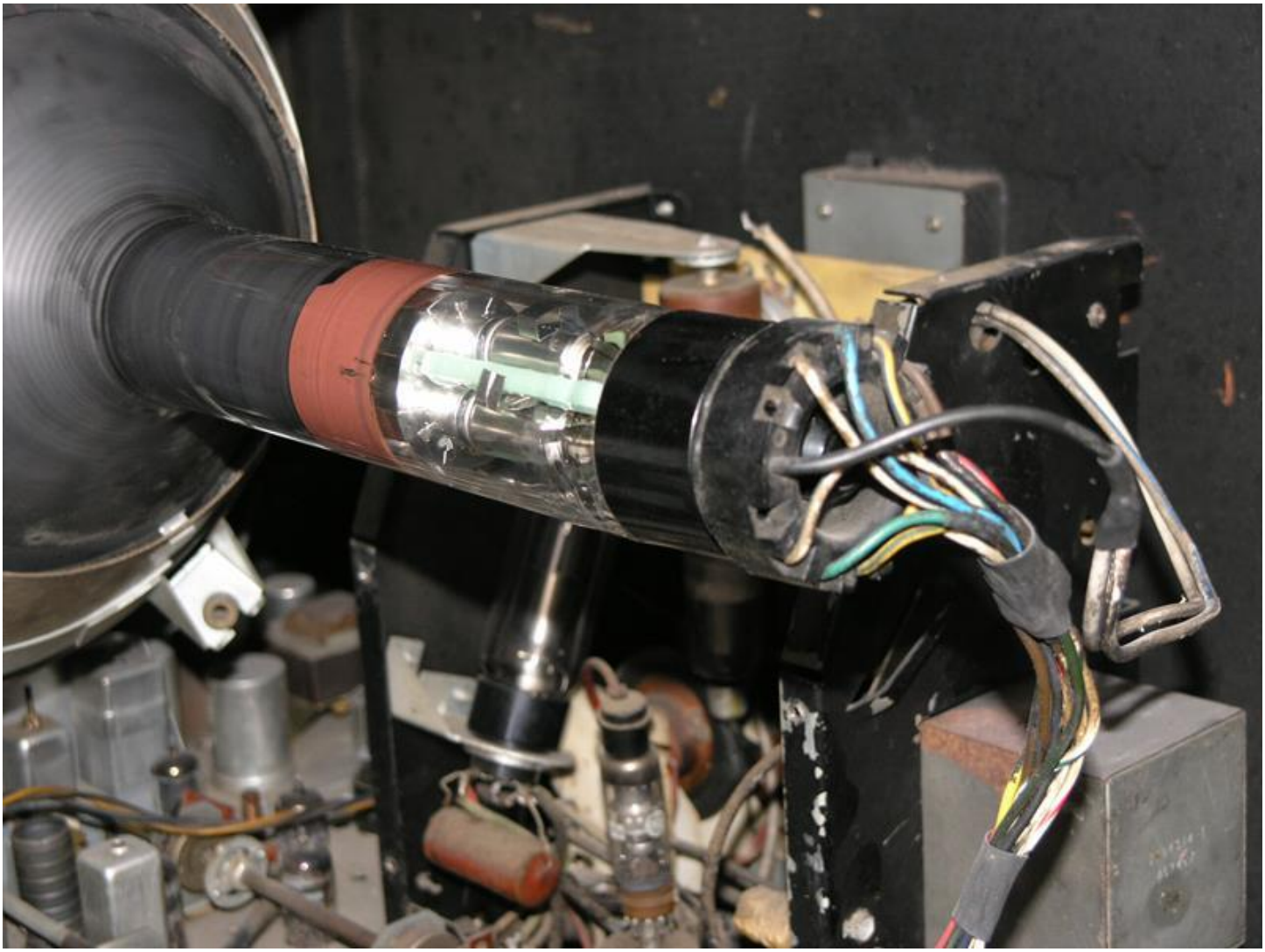


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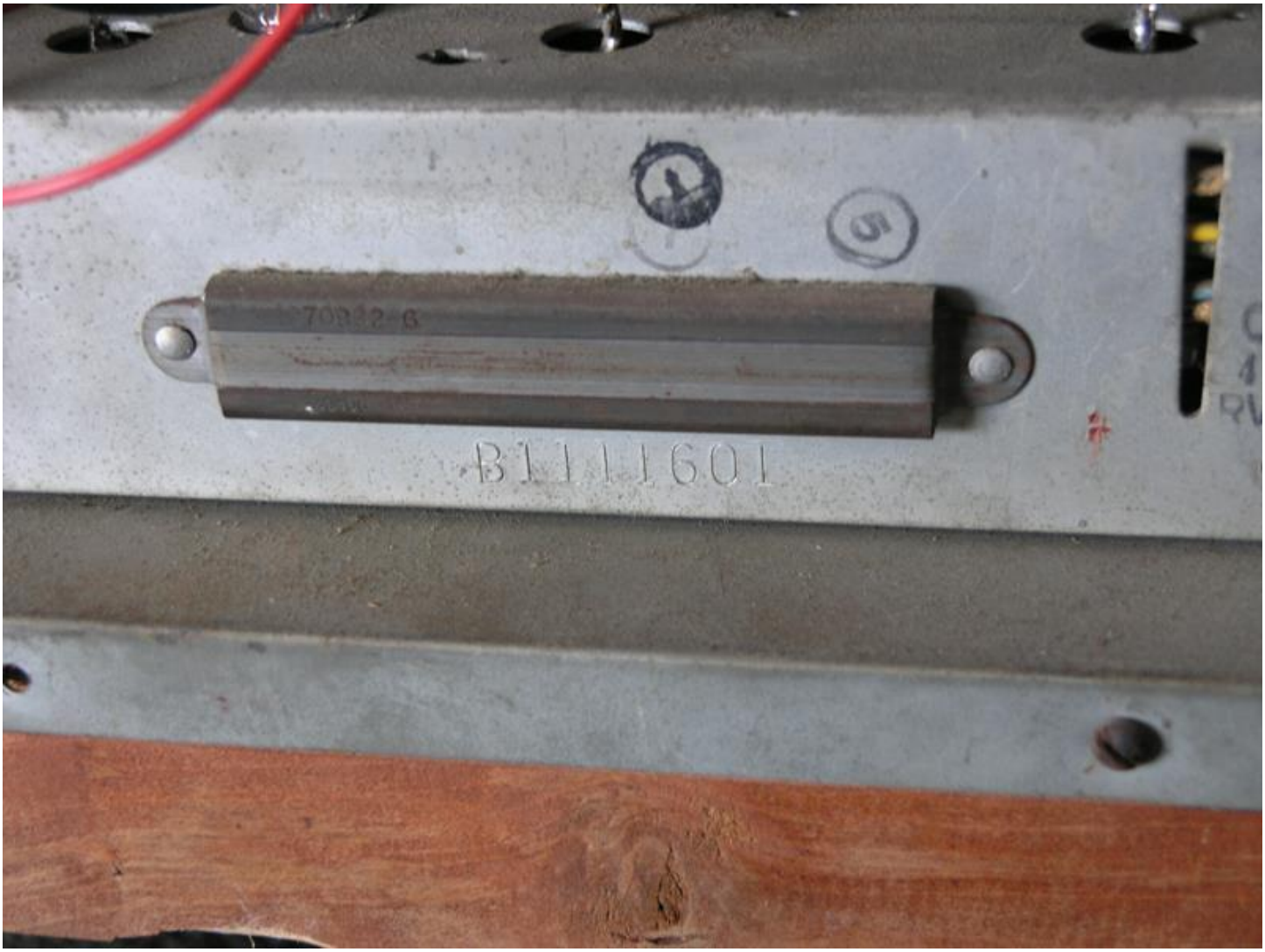
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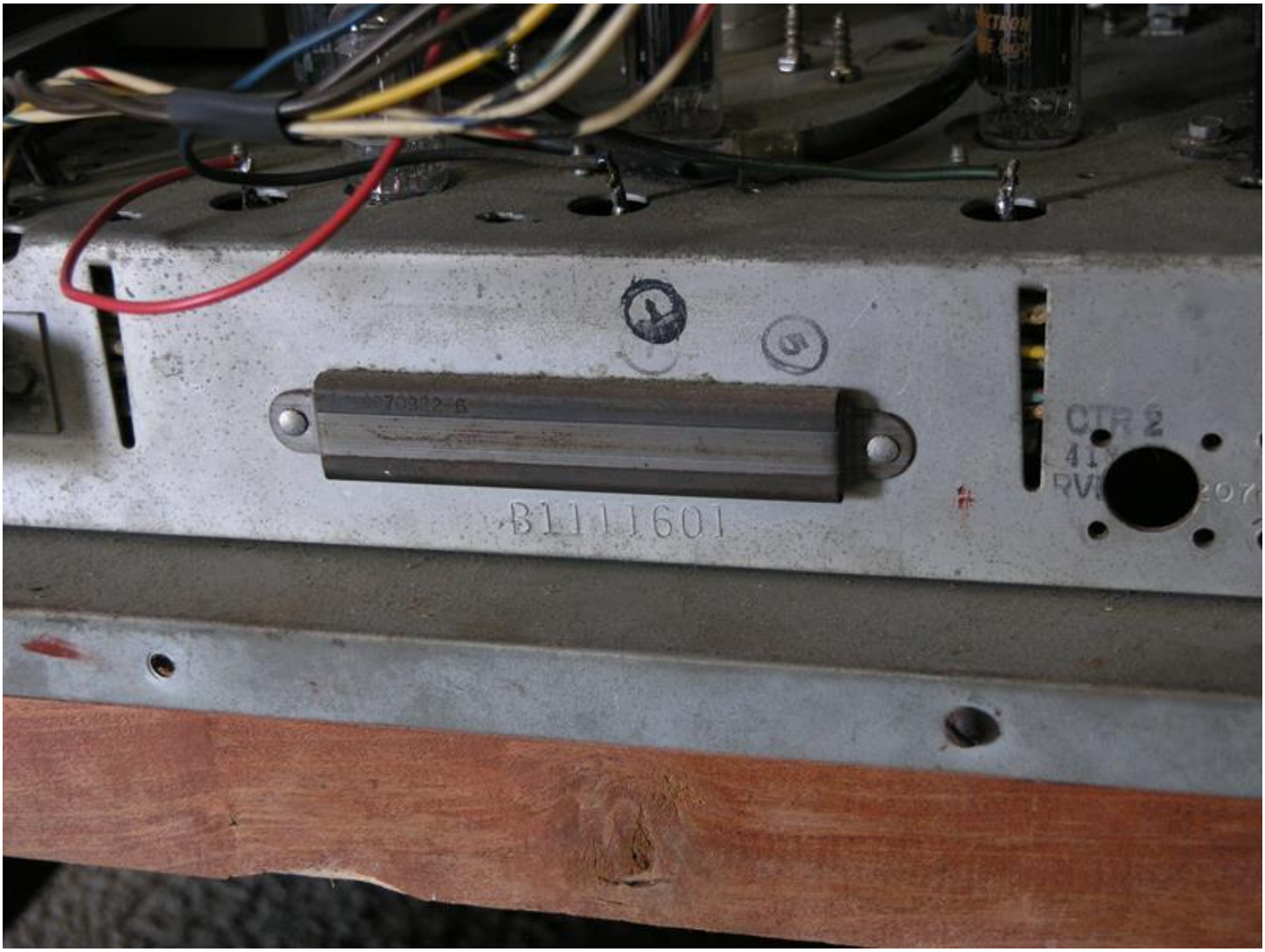
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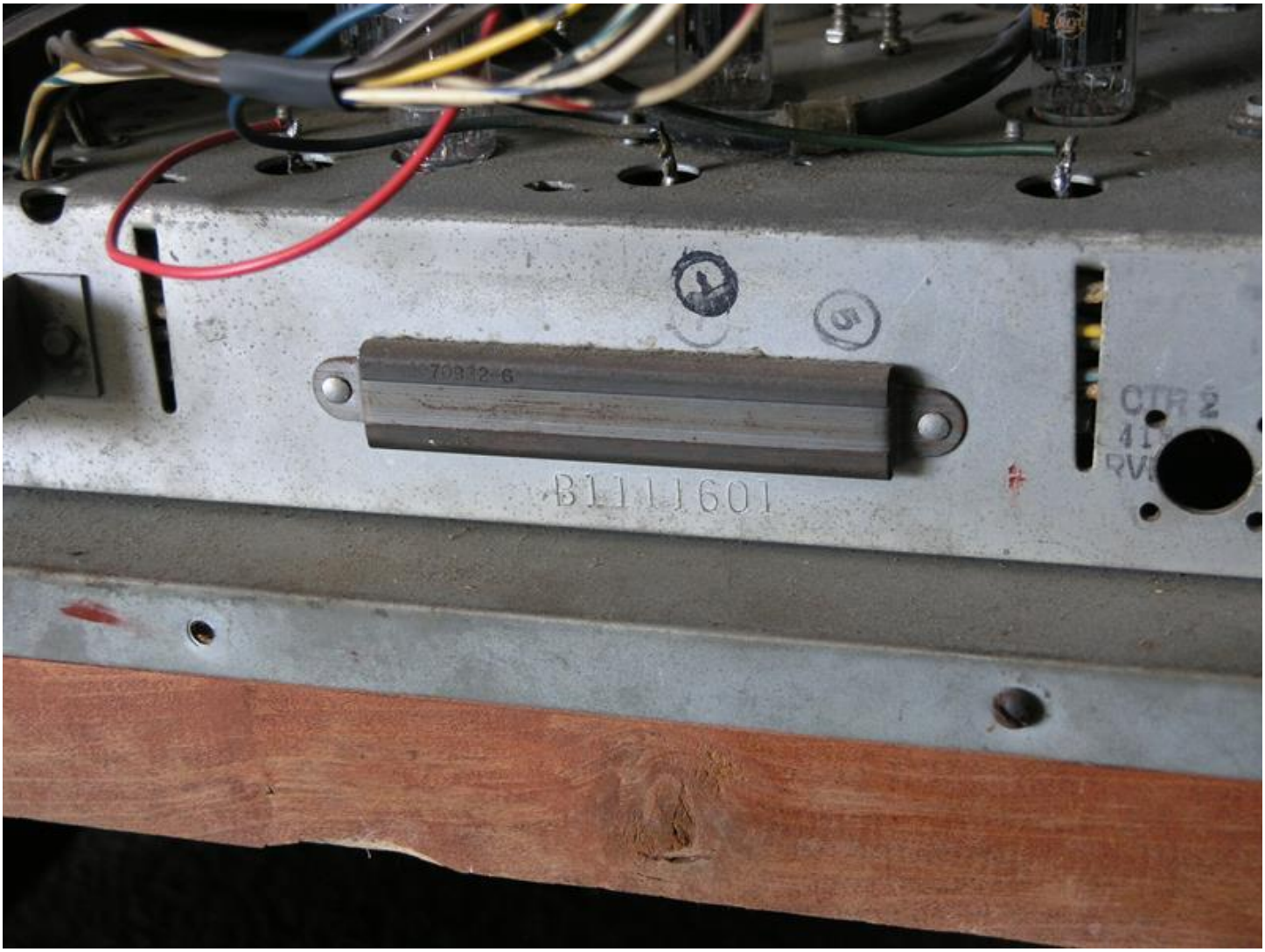
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B1111601
CTR 2


GLASS


GLASS
CATHODE-RAY TUBE


I'D LOVE
TO-VISION YOU
FOR MY VALENTINE


TRADE RECORD inc.
NEW YORK


RCA R-100
Phonograph
Attachment
RCA's TRK-5, 9 and 12 had a connector to allow a phonograph attachment to be plugged in. This one was introduced at the 1939 World's Fair.


MAKA RECORD inc.
60 BROAD STREET • N.Y.C.
Greetings
NEW YORK WORLD'S FAIR
FROM
MANUFACTURED BY ARESTO


MARK RECORD inc.
60 BROAD STREET • N.Y.C.
Greetings
NEW YORK WORLD'S FAIR


MARK RECORD INC.
STREET • N.Y.C.
Greetings
NEW YORK WORLD'S FAIR


EUREKA RECORD inc.
60 BROAD STREET • N.Y.C.
Greetings
NEW YORK WORLD'S FAIR
FROM
MANUFACTURED BY PRESTO


EUREKA RECORD INC.
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Greetings
NEW YORK WORLD'S FAIR
FROM
MANUFACTURED BY PRESTO


URKA RECORD inc.
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Greetings
NEW YORK WORLD'S FAIR
FROM
MANUFACTURED BY PRESTO