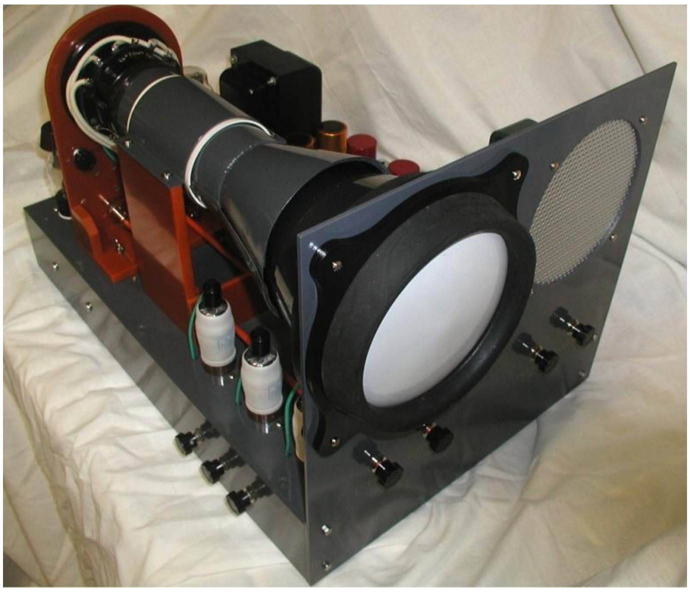
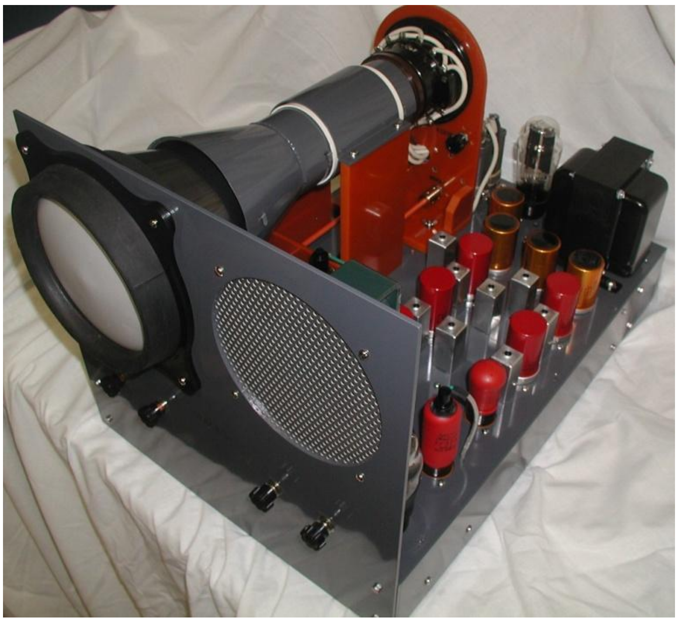
PRACTICAL TELEVISION MAGAZINE'S ARGUS, THE VCR97 CRT, THE PENTODE THAT WON THE WAR and “MY ARGUS”.

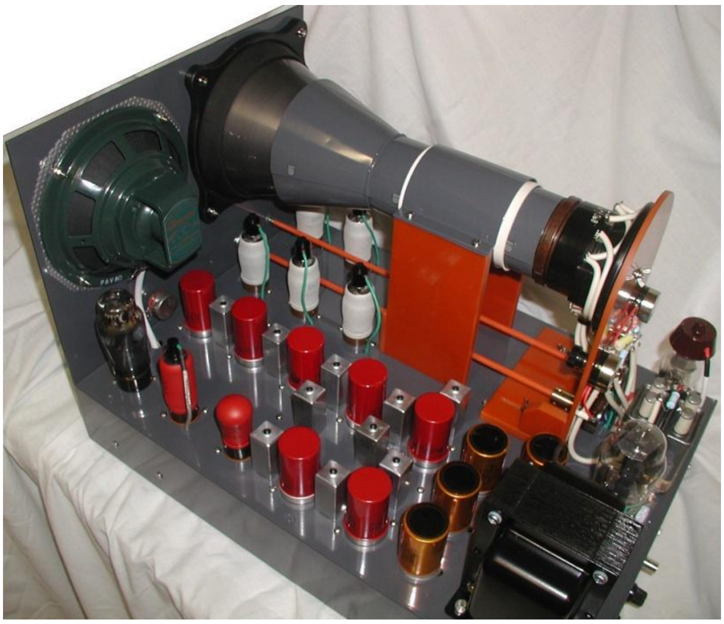
Dr. Hugo Holden, Oct. 2016. **(Updated Nov.2016- Argus Filters & case page 37. Change to sync Sep value, pg 14)**

INTRODUCTION:

Firstly some photos of “My Argus”. This name, throughout this article, refers to my unique version of the Argus build your own Television project from Practical Television (P.T.) magazine 1952. My Argus has a different mechanical construction philosophy and altered electrical design which is described in this article:







SCREEN IMAGES:

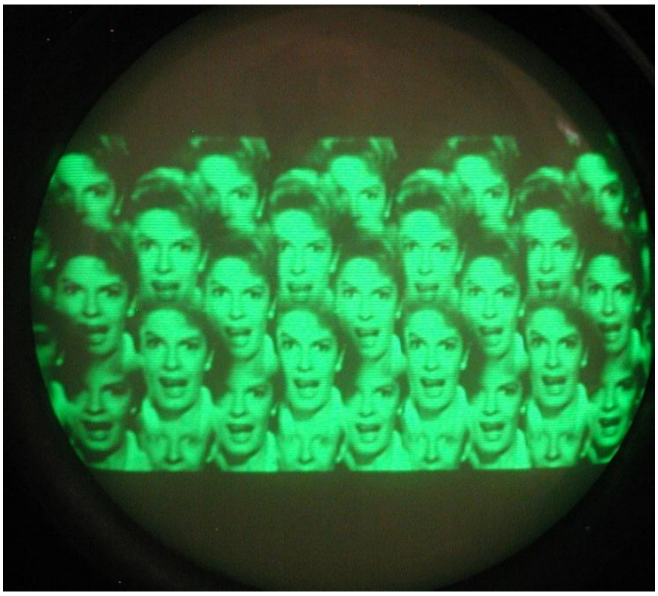
The Argus employed the VCR97 CRT (Radar Cathode Ray Tube).

Just how good is a VCR97 CRT at producing a 405 line television picture? The answer to this question depends on the actual VCR97 you have and the performance of the set's vision amplifier and video output stage. Some VCR97's, due to an anomaly in their electron gun and deflection plate construction, cannot deflect a full screen image. Other VCR97's now have low emission and brightness and while being ok for a single line scope or radar display, are poor for displaying a TV scanning raster. After sorting through a good number of them I selected the better performing tube. A number of screen images are shown below.

The screen image photographs below show that the horizontal and vertical scanning linearity is not perfect. It is a little stretched at the start of the horizontal scan and compressed a little at the end vertical scan. This turned out to have a different reason in the line and frame oscillator/deflection circuits and was subsequently remedied with simple modifications described later in this article. The screen photos shown here are "un-touched up" direct photos of CRT face with the vintage Olympus C-3000 camera and flash off, images reduced in file size only.

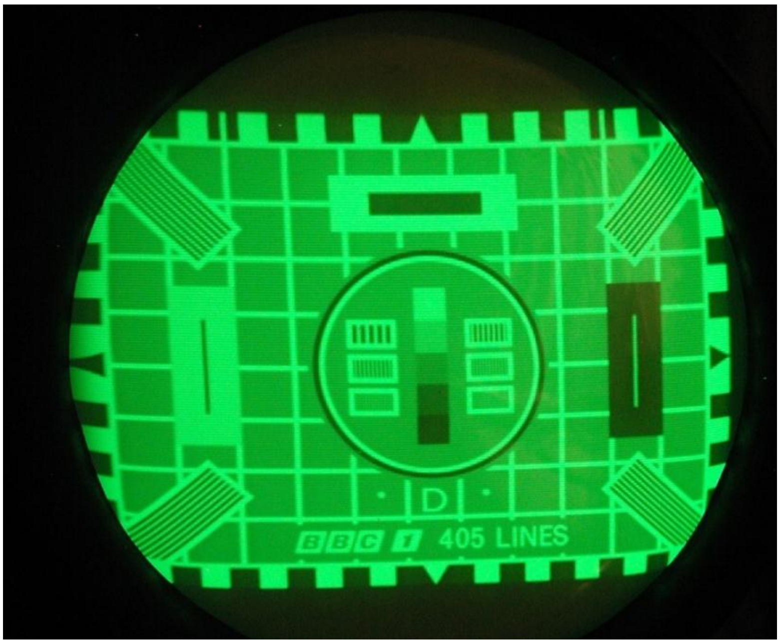
It is actually quite difficult to photograph the face of the picture tube well and get a jpeg image that looks exactly like the actual image seen by the eye on the screen. This is because the light tends to over-expose the cameras acquired image on highlights. For example on the Metro Goldwyn Mayer logo left below, the darker writing inside the bright circle around the Lion's head is hard to see on the photo, but easy to see on the actual CRT image. On top of this most movie images are formatted in wide screen, so the top and bottom of the image are just black bars when the DVD signals are sent via my 405 line standards converter.

The image on the right above is a frame from Forbidden Planet 1956. The one below left is when the Scientist's wife learns her husband has a Fly's head and arm. She screams and the image is supposed to represent a Fly’s eye view or her husband’s view. Of course the Fly’s brain would synthesise the multiple images from its compound eye into a single image (just as our two eyes result in a single image) but the film makers didn’t think of this it would seem. It is a frame from one of my favourite movies; The Fly, with Al. Hedison and Vincent Price. Below right is Hedison with a Fly’s head and arm.



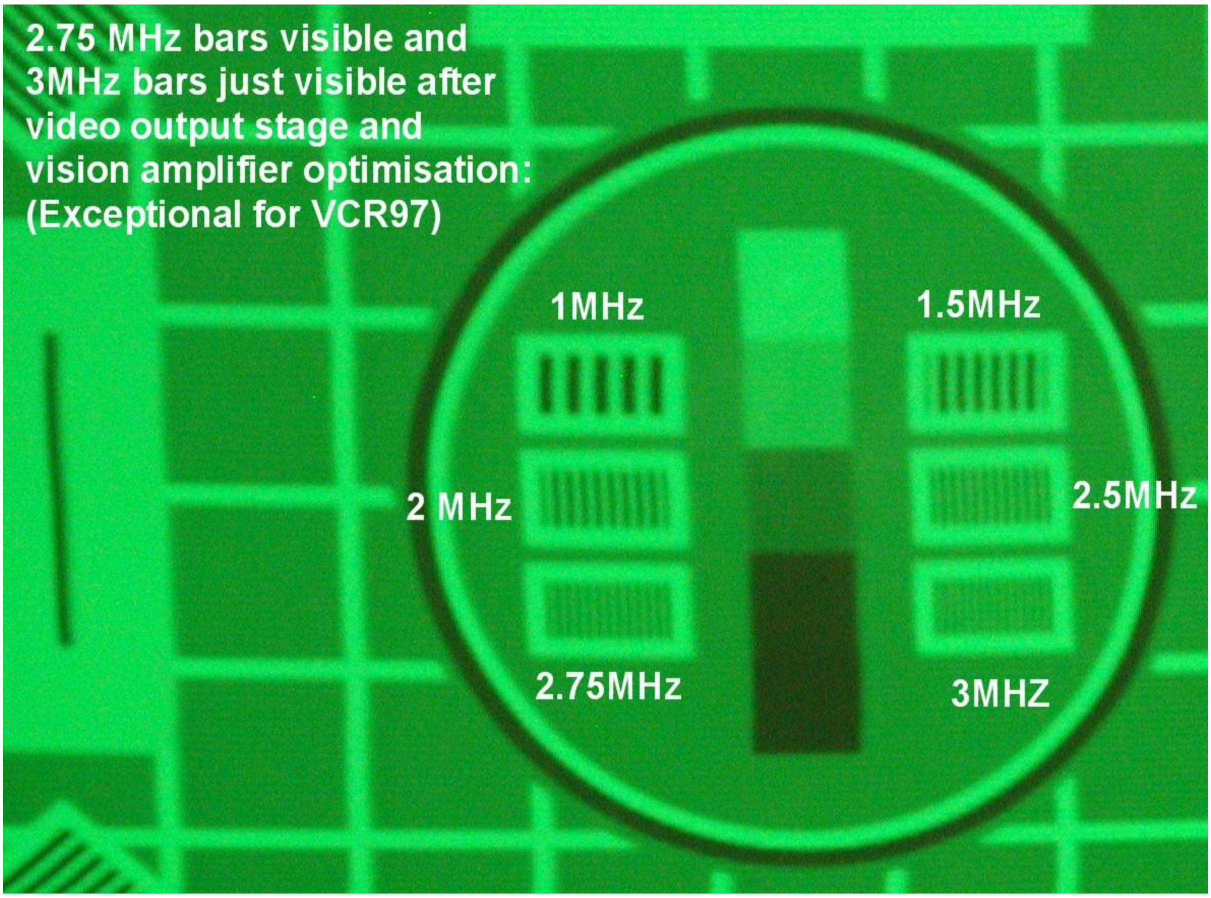
The message in the Fly movie of course is that one small thing like a Fly, or one tiny detail of a large project, could be the monumental undoing of it. Much like the old saying “the Devil is in the detail”. It pays to keep this point in mind when building any complex project.

I spent a while adjusting the tube contrast and brightness and focus and the camera exposure settings to take the best quality photo of the screen image I could get, because the photo doesn’t do the real image justice. A test pattern always tells more about the image quality than any scene from a movie. Most of the images I have seen from green CRT’s, which have been made to show a television image, on various internet published TV projects, have had pretty poor contrast and smeary screen images. However the images here prove that a green VCR97 electrostatic CRT can produce a reasonable quality image.



Each scanning line is just visible on the VCR97 when it is well focussed. In the 405 line system there are 377 active scanning lines. Also the blacks (dark part of the images) look blacker, and the overall contrast looks better, looking at the real screen, than the camera image shows.

The screen photos above were the first I acquired after the preliminary vision amplifier and video output stage tuning. Later, I tuned up the video amplifier with series peaking (see below) and widened the vision amplifier's band-pass response (see sweeps later). The photo below shows that now the 2.75MHz test bars are easily seen and the 3MHz bars are just seen on the BBC "D" test pattern:



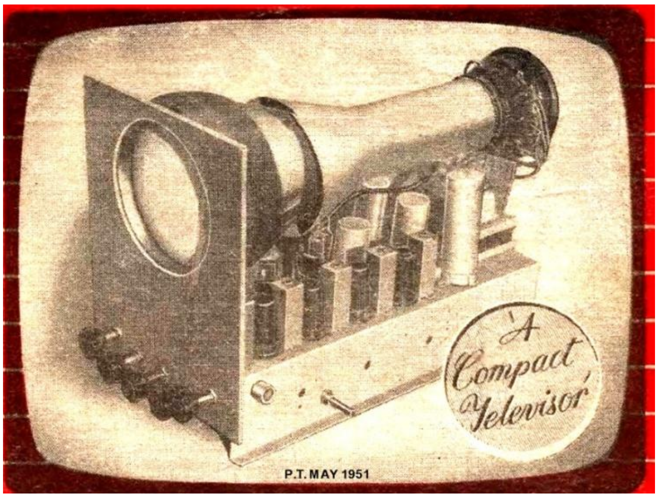
It was stated in P.T. magazine that usually only the 2MHz bars will be visible on a VCR97 CRT, so the above result exceeds what was expected at the time when the Argus was designed.

ENGLISH TELEVISOR HISTORY:

In the decade that followed WWII, home television construction in England was very popular, possibly more so than in the USA because in England there was an abundance of war surplus Radar equipment. This was because Radar technology was pioneered in England.

The surplus "indicator units" from Radar equipment contained nearly everything the home TV constructor needed as the backbone of a TV set; the picture tube, the power supplies, radio frequency tuning coils, tubes such as the famous EF50, tube sockets and many other helpful components. The plan became to convert the Radar Indicator unit into a "Televisor" as it was called then. The common 6 inch CRT in Radar Indicators was the VCR97 but there were other types too.

Construction articles on building sets from scratch or from modified indicators appeared starting in Practical Television (P.T.) magazine from the early 1950's:

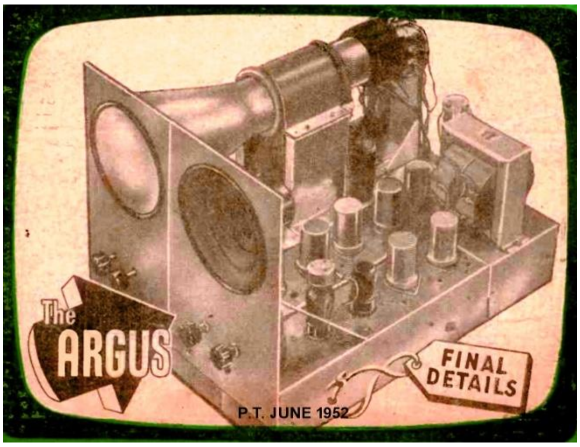


Articles also appeared in June of P.T. 1950 on how to use the VCR97 CRT:

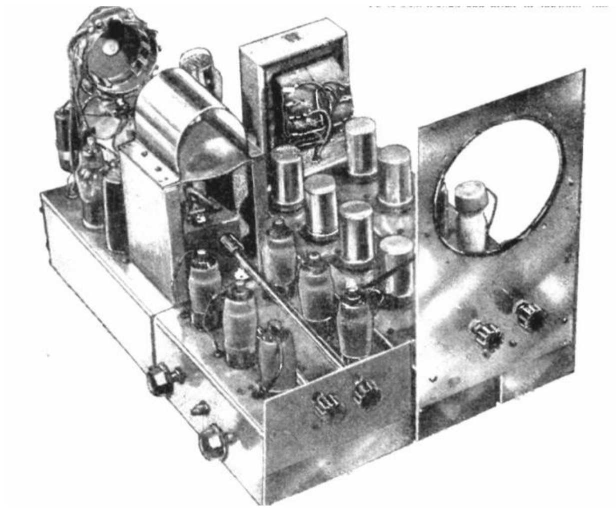
THE P.T. ARGUS:

Many of the modified Radar Indicator units did not have a sound chassis or speaker, so the constructor would make a sound receiver and amplifier/speaker separately.

However by March 1952, P.T. decided to roll their previous work into one receiver, the Argus. By this time they had perfected their designs for the sound channel, the vision channel and the power supplies to support the 21 tubes and the CRT. The project was pretty well completed by June 1952:



Another view with the CRT removed:



The Argus design was broken down into sub-chassis; one each for the low voltage power supply, the high voltage power supply, the line/frame deflection circuits and the sound and vision circuits.

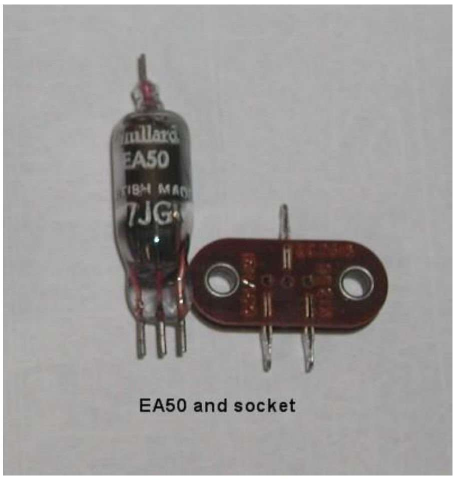
(P.T. supplied a large blueprint to help the constructor, not reproduced in this article, but this blueprint copy is available from Steve Ostler's Radiocraft website).

The basic design revolved around tuned radio frequency stages for the vision and sound channels based on the wonderful EF50 Pentode. It has been said that this pentode "Won the War" because it supported the Radar equipment essential to defeating the Germans; to quote:

"The atomic bomb may have ended WWII, but in many ways it was Radar that won it" - *from the book;* The Invention That Changed the World. Author: Robert Buderi, ABACUS 1996.

The photo left below shows this outstanding radio frequency Pentode with the Air Ministry logo. They were built with a type of Loctal base which resulted in very low inter-electrode capacitances and low lead inductances. When plugged in they lock in very firmly and will not shake loose from their socket, making them suited to airborne equipment. Also being encased in a metal shell, they are perfectly shielded:


THE EF50



EA50 and socket

For diode and detector work in Radar Indicators and Televisors, the companion diode to the EF50 was the EA50, shown with its socket on the right above. The EA50 is used for video detectors, audio detectors, DC restorer diode for video and they are also used in noise clippers and AGC circuits. They have very low capacitances. (In the USA the diodes used in TV's in the 1950's era were usually the 6H6 and then later the 6AL5. Also, in the Pentode department, the Americans were using the 6AC7 as their "more or less equivalent" of the EF50 but they have an ordinary octal base).

Thinking back, I first saw an EF50 with the AM markings and crown logo on them in the early 1970's when I was 13 years old. I had an ex WWII radar indicator from an army surplus store and the EF50 tubes stood out due to their bright red colour and I marvelled at them and wondered about them. Needless to say, they made a lasting impression on me, leaving me wanting to build something, one day, which used the EF50.

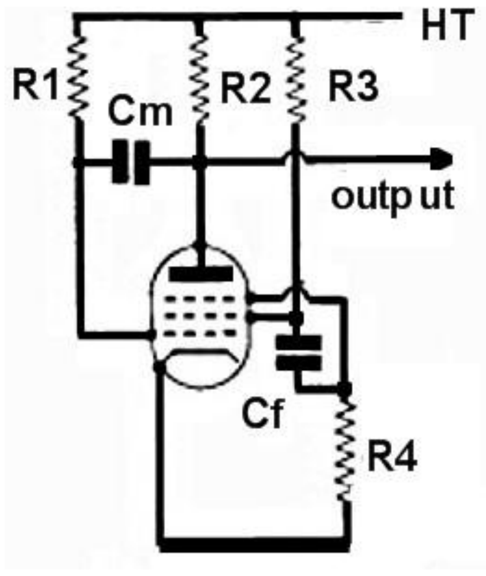
LINE AND FRAME SCANNING OSCILLATORS:

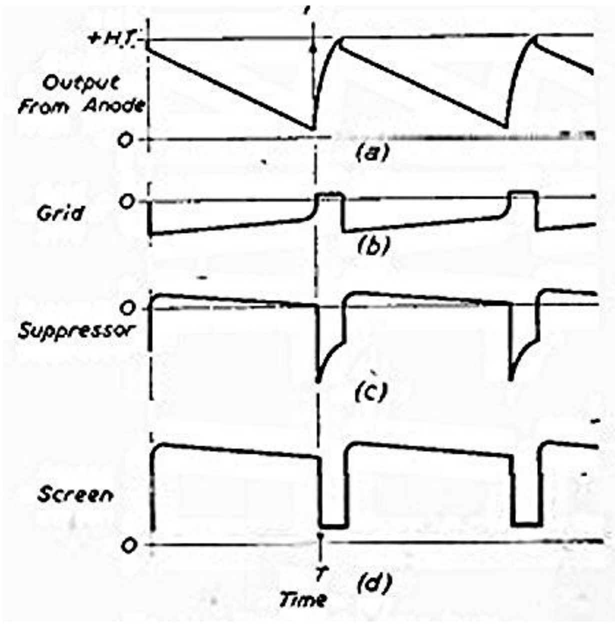
Other tubes used in the Argus include the SP61 pentode. These are a good glass metallized RF pentode and they are suited to work in the Miller-Transitron CRT beam deflection/scan circuit.

The frame (Vertical scan) and line(Horizontal scan) time-base oscillators in most American TV sets of the 1939 to 1960's era were usually either blocking oscillators requiring a coupling transformer and one triode, or multivibrator circuits requiring typically two triodes.

However, the circuit favoured by the British, especially for electrostatic TV sets for the hobby market, was the Miller-Transitron circuit. This is a unique and interesting arrangement based on one pentode. Use is made of the suppressor grid to sustain oscillations.

The Miller –Transitron circuit is shown below left. The AC feedback via capacitor Cf, between the suppressor and the screen grids, sustains oscillations causing the tube to alternately switch into a conducting and non conducting state, this forms the Transitron Oscillator. The feedback via Cm (added Miller capacitance) turns the tube into a linear integrator and ensures that when the tube is conducting the ***fall*** in (anode)plate voltage is substantially linear. The waveforms (from P.T.) for the anode, grid, suppressor and screen voltages are shown on the right:





In general though most electrostatically deflected CRT's, when used for TV work, require a symmetrical anti-phase sawtooth drive for each pair of deflector plates. This avoids the trapezium distortion in the scanning raster seen when only one deflection plate is driven. So the output of the Miller-Transitron oscillator feeds another stage to give a symmetrically opposite phase saw tooth wave.

The circuit below is the Argus line and frame deflection arrangement. But the same circuit, sans a few small changes, appeared in P.T. in 1951 prior to the Argus project:

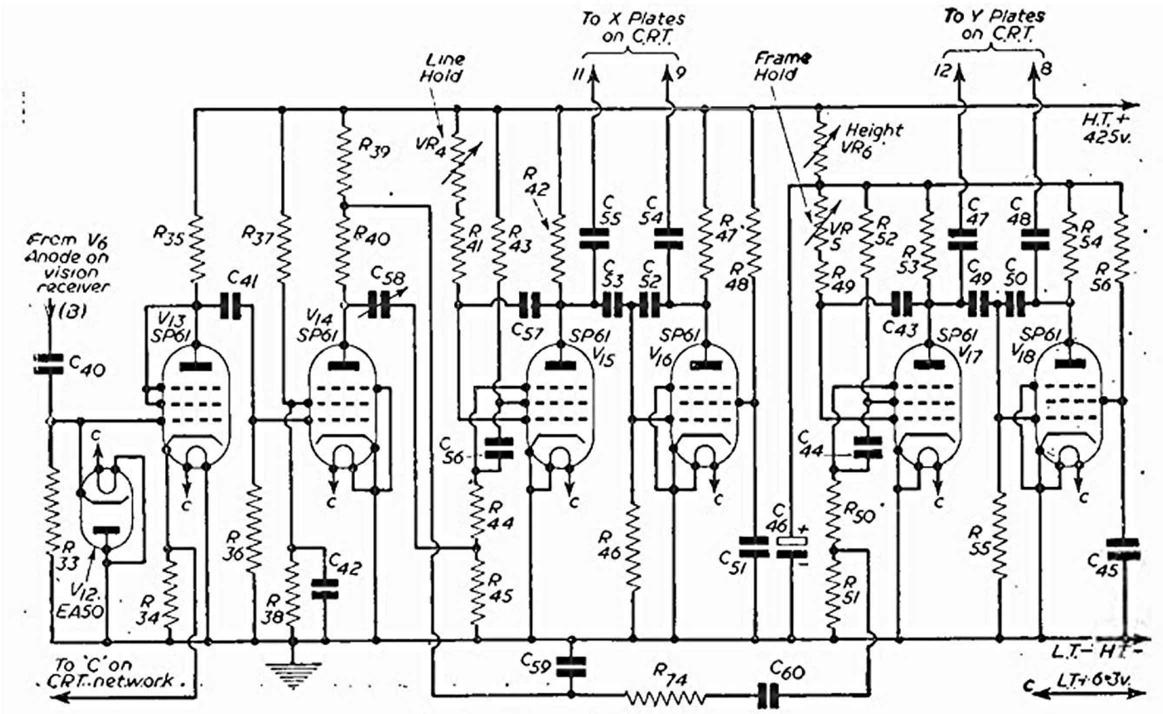
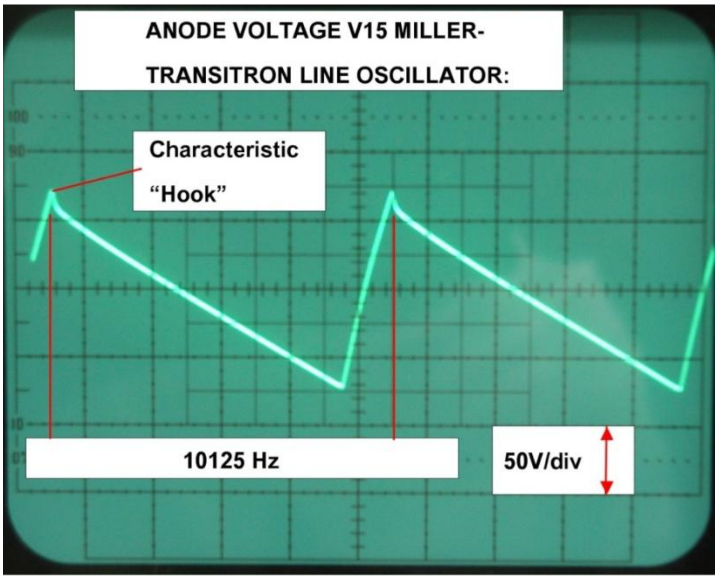


Fig. 6.—Theoretical circuit of the time base.
P.T. Argus April 1952

V15 and V17 are the Line and Frame "Miller-Transitron" oscillators respectively. V16 and V18 are the inverting amplifiers. In fact, it turns out, that they are not really inverting linear amplifiers at all, but another Miller integrator (see below).

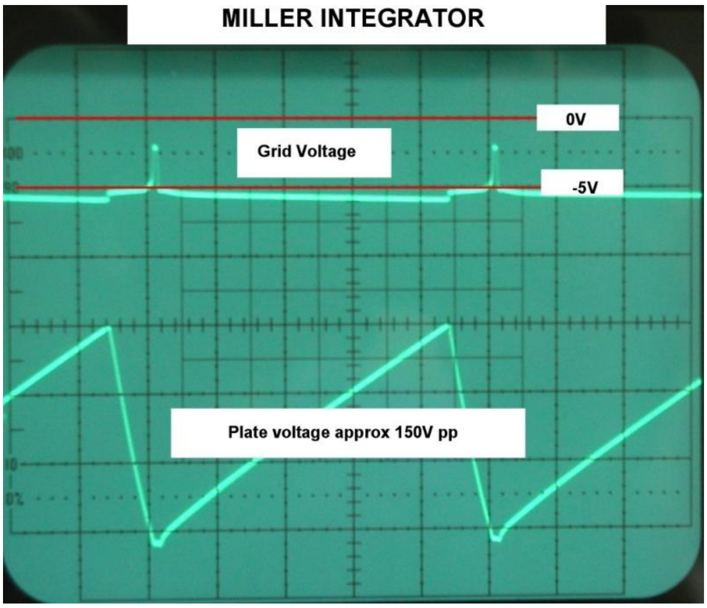
LINE LINEARITY:

It is worth noting that the sketch from P.T. above right on the previous page was very accurate for the Miller Transistron oscillator's anode (plate) voltage. Especially so for the line scanning stage operating at 10125Hz. There is the presence of a small "hook" in the sawtooth wave at the end of flyback. Due to the much slower operation of the frame stage (50Hz) the hook is not seen in that stage and is far too brief. The scope recording below shows this characteristic hook. Unfortunately this feature causes the horizontal scanning linearity defect on the left side of the raster, stretching it a little due to the more rapid rate of change of the waveform:

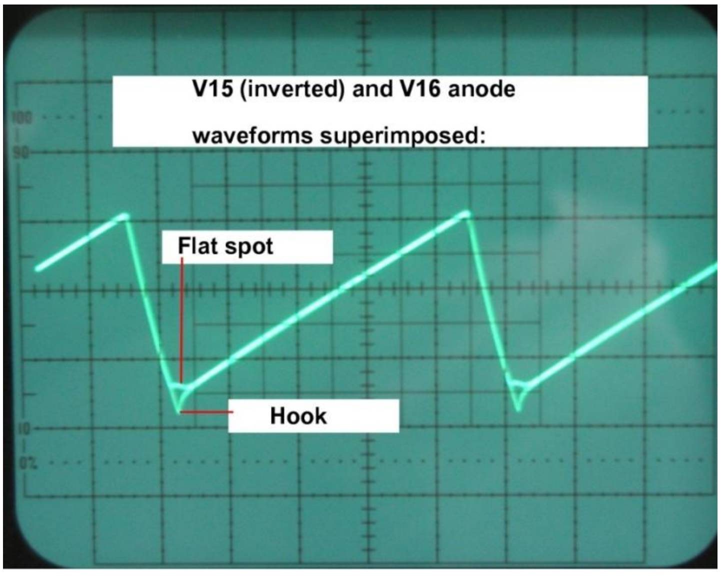


Modification of this oscillator stage itself failed to provide a successful method for improving the horizontal linearity and eliminating the hook. However modification of the inverting stage gave the answer. Since it is a push pull or anti-phase drive to the CRT’s defection plates then the other waveform can be modified to correct for the hook.

Looking at the grid and anode waveform of the inverting amplifier (another miller integrator) V16, showed that in fact it was not operating in a linear mode at all. The scope recording below of V16’s anode and grid voltage shows what I found showing that the tube also was drawing grid current at the end of flyback:



I found that I could delay the start of V16's anode voltage rise by adding a 250pF capacitor across R46 (V16's grid resistor) to elongate the flat spot in the initial part of V16's anode waveform. In the recording below the anode voltages of V15 and V16 are superimposed and V15's signal is inverted by the scope. The flat spot created in V16's waveform compensates for the hook in V15's anode waveform and the net result being improved horizontal scan linearity:



Despite adding the 250pF capacitor across R46, it was not necessary to increase the coupling capacitor C53 or the integration capacitor C52.

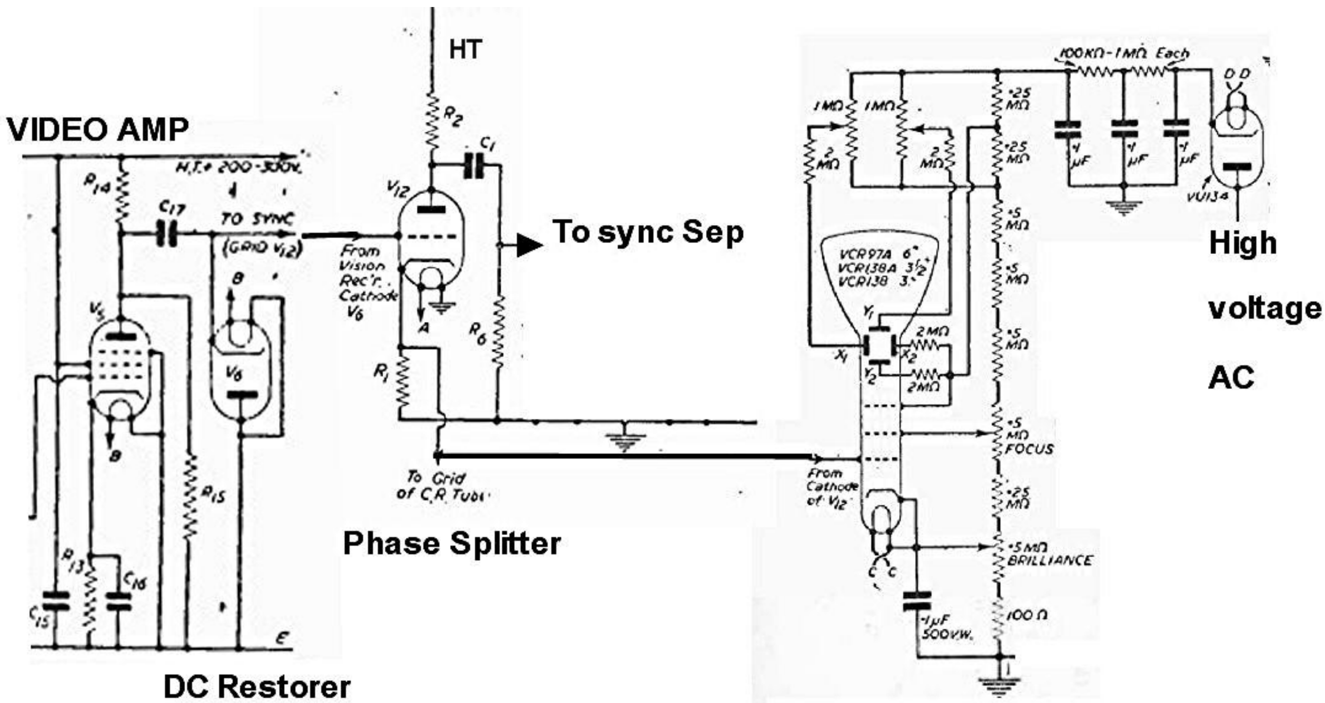
FRAME LINEARITY:

In the case of the frame linearity defect with some crowing of the scanning lines towards the end of scan (lower 1/3 of the raster) the cause turned out to be quite different and very simple. The screen grid of V18 has a hopelessly inadequate value bypass capacitor and over 50V of ripple at vertical rate appears on the screen grid. While a 0.1uF capacitor (as specified in the Argus circuit) is perfectly adequate to bypass the screen grid in the line stage inverting amplifier V16, in the much lower frequency frame stage of V18 it needs to be at least 2uF. So simply to cure the frame linearity defect; C45 (a 0.1uF) was changed to a 10uF electrolytic capacitor. This results in perfect frame scan linearity.

Unnecessary EA50 diode in the Argus:

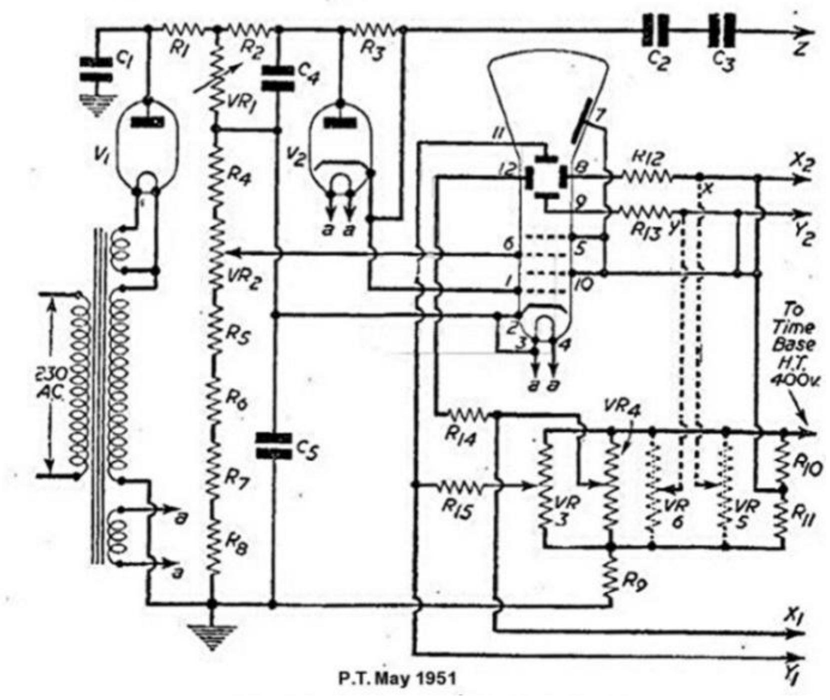
It is worth noting at this point an interesting issue with the phase splitter and sync separator circuit above which resulted in the Argus containing a completely unnecessary EA50 diode (V12). In the earlier 1951 version of the circuit the DC restorer at this circuit location was necessary. It took some research reading many early P.T. magazines to find out how this anomaly came about:

In the original Radar indicators which were converted by P.T. to Televisors, around 1950, the CRT's EHT power supply was a conventional negative ground. On account of this the cathode of V13 (the phase splitter stage in the diagram above) was **direct coupled** to the grid of the CRT. This required DC restoration by an EA50 diode at the grid of the phase splitter to maintain the DC axis of the video signal at the CRT grid. Shown below is an earlier circuit from P.T. (from August 1950) where the phase splitter stage is labelled as V12 and the DC restorer EA50 diode labelled as V6. It is a direct coupling system from the phase splitter output load (cathode and R1) to the grid of the CRT:



PRACTICAL TELEVISION AUGUST 1950

However, for the Argus, which appeared in March 1952, they had gone to a positive ground EHT system. This required that a high voltage coupling capacitor/s be installed between the output of the phase splitter's cathode and the CRT's grid. This required an additional EA50 DC restorer diode (with a well insulated heater supply, V2 below) be added to the grid circuit of the CRT. The circuit for this configuration, which is the same as the Argus is shown below:



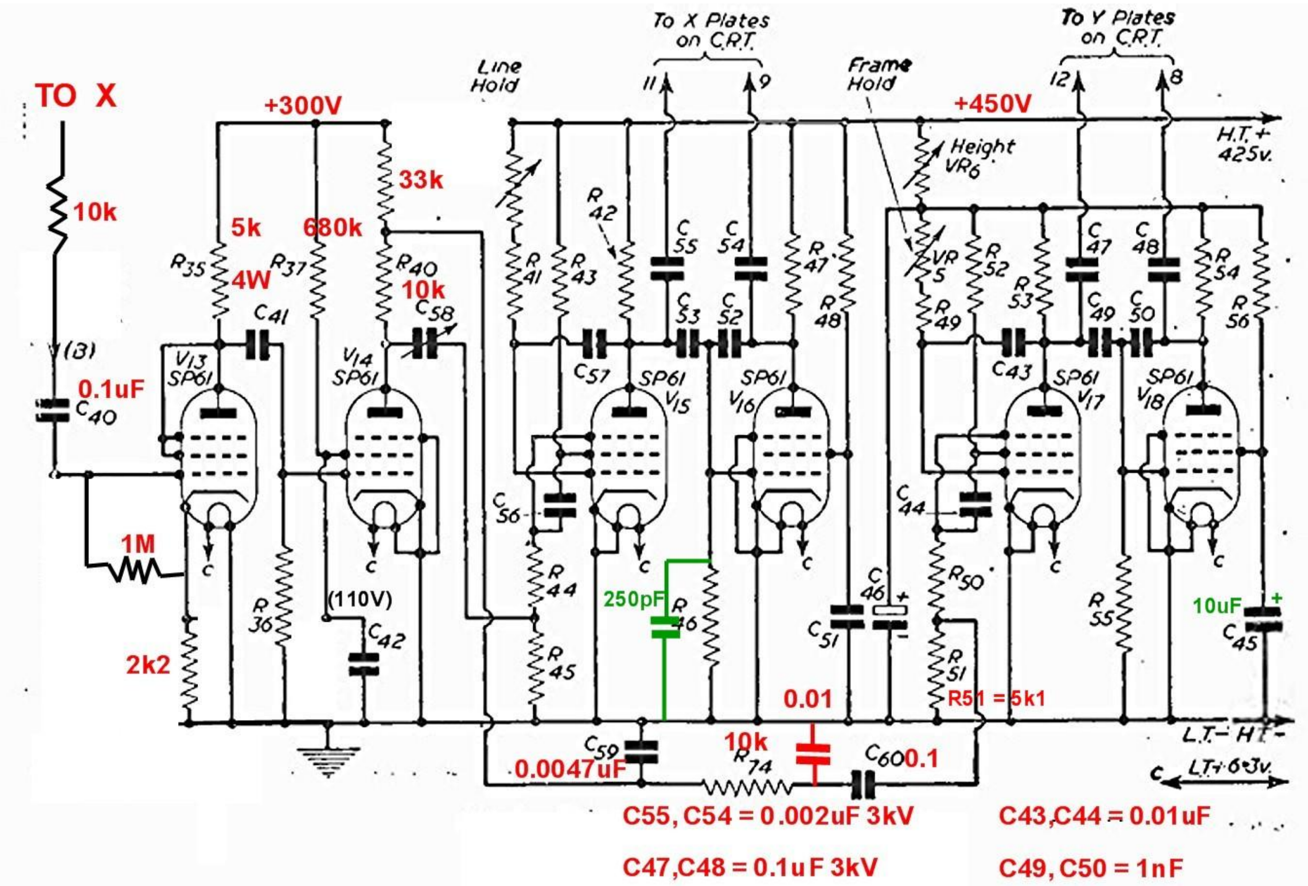
The connection Z in the diagram above connects to the output (cathode) of the phase splitter.

Therefore, it turned out that AC coupling on both the input and output of the phase splitter V13 (of the original Argus circuit) makes the original EA50 DC restorer diode (V12) in the grid of V13, in the Argus, totally redundant. It appears that nobody thought to remove it from the Argus design. But why could this not have been noticed?

Perhaps one reason that this anomaly persisted throughout a number of P.T. projects, including the Argus, is that if the EA50 in the grid circuit of the phase splitter is removed experimentally, the sync separation immediately fails because the phase splitter bias is incorrect for linear phase splitting and the tube is driven into cut-off by the sync pulses. So the experimenter concludes that the diode is a “required part” because the picture synchronisation fails when the diode is physically removed.

However, if the phase splitter is correctly biased by returning its grid resistor to its cathode (and not to ground) correct function is assured and it becomes obvious then that the EA50 in the phase splitter grid circuit serves no function and is not required. So this EA50diode was eliminated from “My Argus” in this manner.

The modified circuit I used is shown below (the linearity mods are shown in green).



Sync Separation:

Sync separation occurs by sync tip rectification at the grid of V14 which draws grid current on the positive going sync tips and charges capacitor C41 in a similar manner to a DC restorer. This clamps the positive going sync pulse tips at a DC level close to ground.

As noted above the feed to point X for the phase splitter stage also has a series 10k(changed to 1k later for better H sync). resistor not present in the original design. This resistor helps isolate the input capacitance of the phase splitter V13 from the video output stage's load (it is also tapped down that load, see below)

Since My Argus uses a standard negative ground EHT system, high voltage rated coupling capacitors are required for the deflection plate coupling. Typical values for horizontal or line scan coupling in American electrostatic TV sets were 0.001uF. In the Argus they specified 0.1uF for the line scan which is way bigger than required coupling in to a 4.7 meg-Ohm load resistor. Testing with the 10125 Hz horizontal scan output; a 0.002uF capacitor was ample so 0.002uF 5kV rated "Vitamin Q" capacitors were used for the horizontal coupling with no degradation at all to the existing horizontal scan linearity or picture width. However, 0.1uF coupling capacitors, as specified in the Argus circuit, are definitely required for the frame deflection.

Sync Separator and Vertical Integration Time Constant Issues:

In some early circuits and some suggested sync pulse circuit modifications for the Argus, the correct time constant for the vertical integrator circuit that filters off the frame sync pulse was not thought out well. Sometimes, the time constant chosen for the integration was far too long, in some circuits by a factor of 10. With excessive integration the vertical sync is weak and the vertical sync signal has a slow rising edge. Too little integration and the horizontal pulses are not adequately filtered and poor interlacing results. Generally, the original Argus values were good, though it was only a single stage filter and ideally it should be a two stage filter at least.

Generally a two stage filter (series resistor or source resistance R1 capacitor C1 to ground, then another series resistor R2 and capacitor C2 to ground) with an *overall* time constant of around 150 to 300uS is perfectly adequate. The overall time constant for a two section filter can be calculated by R1(C1 +C2) + R2C2.

As shown above, I modified the vertical integrator into a two stage filter and lowered the value of R51 and R74. These modifications were made to My Argus circuit to get a suitable time constant and correct vertical sync injection level to the frame Miller-Transitron oscillator. In addition the phase splitter and sync separator stage is now powered by the well filtered +300V supply, not the +450V supply running the deflection stages. With the single 680k screen resistor, the screen voltage of the sync separator stage V14 runs around 110V and is well filtered by C42.

The Vision Receiver, Video Output Stage and Detector Frequency Responses:

There seemed to be an "interesting design feature" in the Argus video output system's connection to the CRT grid. This again appears to be a hangover from the fact that P.T's Televisors were derived from modified Radar indicators.

It is very important, for a good television image, to maintain the high frequency response in the video output stage feeding the CRT's grid or cathode, ideally flat to at least 3MHz. This to a great extent relates to keeping the circuit and stray capacitances as low as possible in the video output stage's plate (anode) circuit. Ideally, the stray and CRT grid capacitances are tuned with inductors either in series or shunt peaking combinations to improve the high frequency response. Manufacturers of many TV types realised this and the physical feed wire from the video output stage (to the grid or cathode of the CRT) is a single wire and ***not shielded.*** This is because coaxial cable has a significant capacitance per foot often as much as 20pF/foot. Capacitance rolls off the high frequency response.

In addition the grid or cathode circuit in a TV is a "high dynamic voltage level circuit" the grid drive voltage being around 20 to 30V pp for full contrast. 10's of millivolts of any stray pickup is not seen in the picture. Pickup of stray signals is not extreme either because the video output circuit's impedance is usually 10K or less. Unlike a scenario with a 1 meg-ohm grid circuit operating with low level signal such as the input of an audio amplifier that does need shielding. So in fact shielding is not required for the grid or cathode feed to a CRT in a

TV set and it should be a single wire run directly from the video output stage to the CRT, not coax. If this wire has a fair way to travel, it should be spaced away from the chassis at isolated intervals with small mounting clips (see under-chassis photo below).

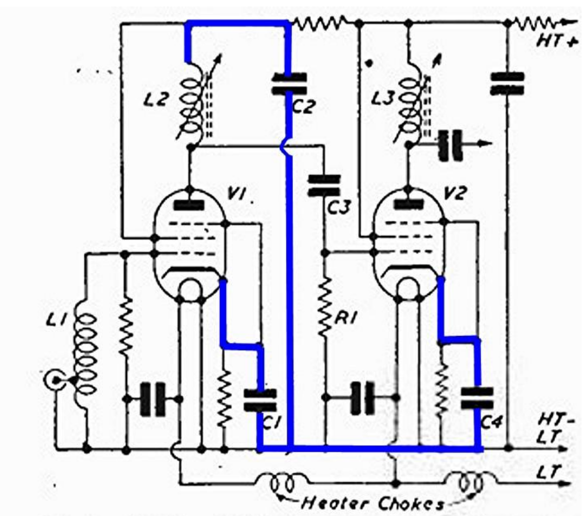
The P.T. Argus (and other Televisor circuits from the early 1950's) all had a coax cable feeding the CRT grid as this was pre-existing wiring in the Radar indicator units. It appears to some extent that this wiring technique was slavishly copied for the Argus. In the Radar indicators and the Argus, capacitance of the cable was to some extent offset by the fact that the phase splitter stage, acting as a cathode follower, lowered the source of impedance of the video signal to a low value. The source impedance of a cathode follower output is often in the order of a few hundred ohms.

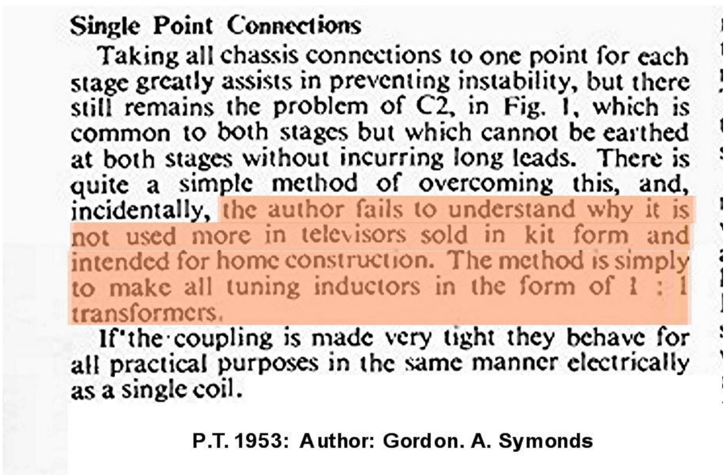
However it is still better to avoid added capacitances. Good results are obtained if the video signal for the CRT grid is taken directly from the video output stage anode circuit, with at least a series peaking coil to maintain the upper video frequency response. A 250uH peaking coil was added to the circuit for My Argus. Shunt peaking also works, as does the combination of series and shunt peaking. This "combination peaking" became industry standard in America at least by the late 1950's because it gives a good frequency response with the highest possible overall gain. Likewise the video detector's frequency response is important. Also and just as important for a crisp picture, the tuning of the vision receiver is staggered for an overall wideband response.

RF Transformers for My Argus - Five benefits of Bifilar wound coils:

RCA engineers very early in the piece concluded that the better method to design the dust iron cored inter-stage radio frequency (RF or IF) transformers for a vision amplifier (or vision IF amplifier) was to ***bifilar wind*** the coils. This eliminates the need for a coupling capacitor and saves a part. But also, if the coupling capacitor is present, it gets charged by noise pulses causing too much negative bias trailing after noise peaks in the signal (Grob, Basic Television, 2nd Edn. McGraw Hill 1954, pg 424)

RCA were not the only ones who realised the advantage of a 1:1 or bifilar coil. It turns out there are other reasons why it is advantageous over any other coil design for this application. Firstly, it results in improved stage stability; taken from P.T. August 1953:



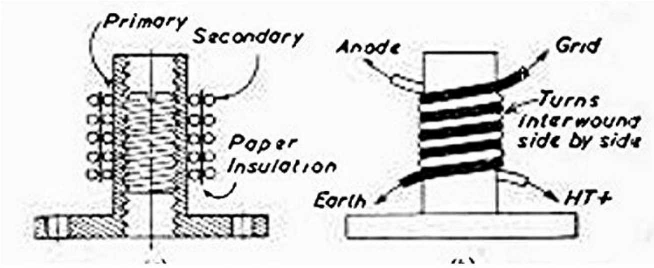

Single Point Connections

Taking all chassis connections to one point for each stage greatly assists in preventing instability, but there still remains the problem of C2, in Fig. 1, which is common to both stages but which cannot be earthed at both stages without incurring long leads. There is quite a simple method of overcoming this, and, incidentally, the author fails to understand why it is not used more in televisors sold in kit form and intended for home construction. The method is simply to make all tuning inductors in the form of 1 : 1 transformers.

If the coupling is made very tight they behave for all practical purposes in the same manner electrically as a single coil.

P.T. 1953: Author: Gordon. A. Symonds

The 1:1 Design suggested by Mr. Symonds below includes the bifilar option:



P.T. August 1953. Gordon. A. Symonds.

I agree with these remarks and like Mr Symonds I fail to understand also why this design was not commonly recommended. Sometimes really good things like this get overlooked.

And secondly, due to the tight coupling of the bifilar coil, more energy is transferred to the next stage and the gain is higher than when two coil systems are more loosely coupled. And finally the bifilar coil is extremely easy to construct.

In summary there are five things in favour of the bifilar coil:

1) Reduces the component count by one capacitor per stage.

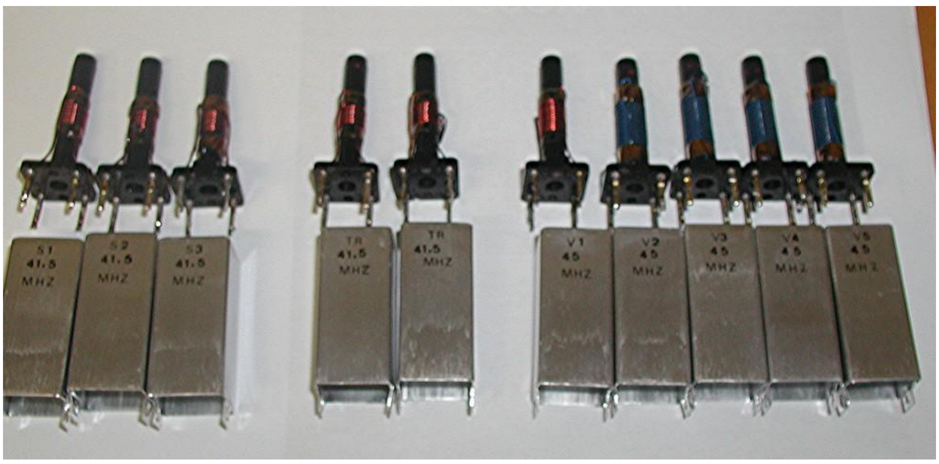
2) Improved noise response.

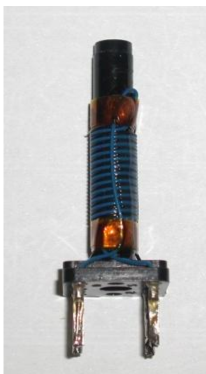
3) Improved stage stability.

4) Couples more energy to the next stage compared to more loosely coupled coils.

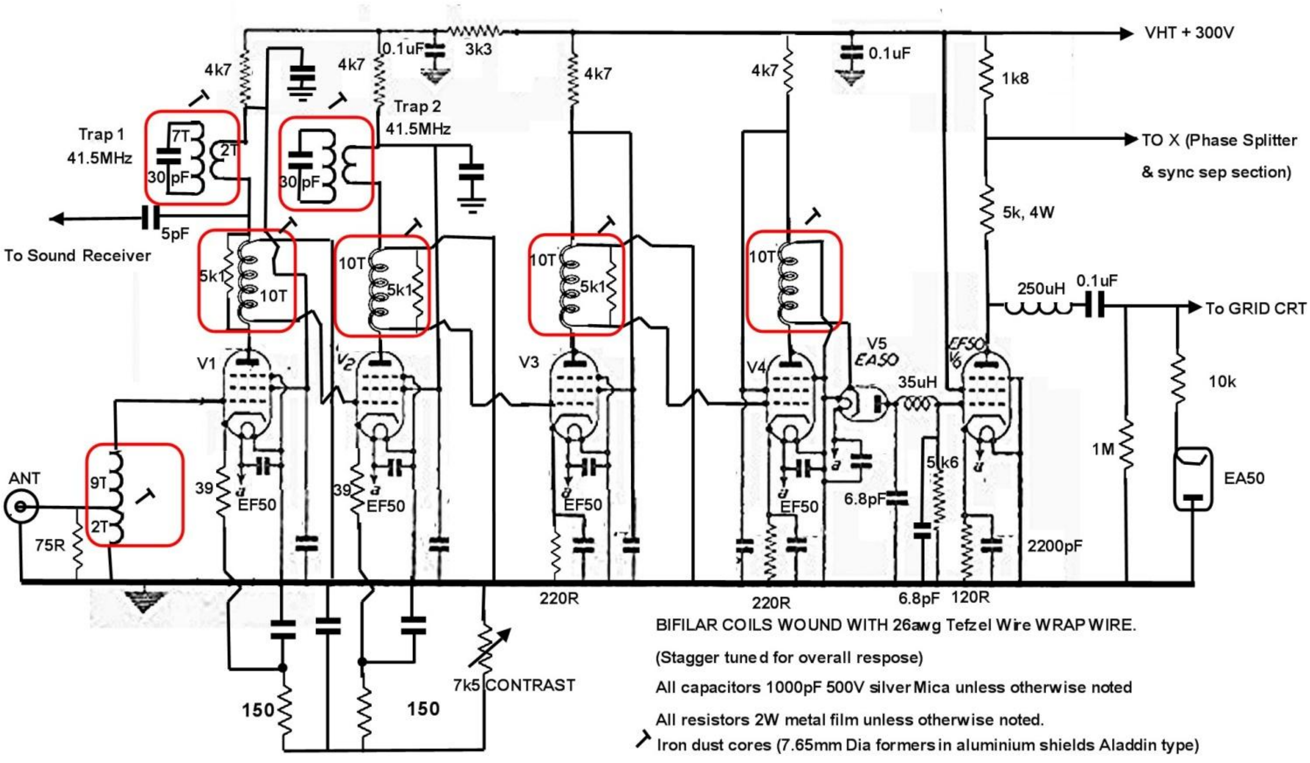
5) Easy to wind.

So I decided to make the vision amplifier coils (and two sound amplifier coils) bifilar, simple to wind and tune. Also nearly all the coils in My Argus are inside shielded cans, that way the awkward under chassis shields of the original Argus are not required and the Chassis can also easily be one piece. The bifilar coils were wound with Teflon coated wired wrap wire, a photo below shows the coils used in My Argus along with the other coils. The formers and cans were originally for 10.7MHz IF use and rewound. If the bifilar windings are different colours (black and blue in this case) there is less chance of mixing them up. It is important that the grid and the plate connection have the same phase relationship.





The circuit below is the modified Vision amplifier I used in My Argus. The usual damping resistors help broaden the bandwidth of the stagger tuned stages:



“MY ARGUS” EF50 VISION RECEIVER. H. Holden. 2016.

Also to further isolate capacitive effects on the video output amplifier’s plate circuit, the signal feed to the phase splitter is tapped off the video output stage’s anode load across the 1k8 Resistor. Notice how the capacitance of the DC restorer diode is also isolated by a 10k resistor too. This was a common technique in American DC restorer systems.

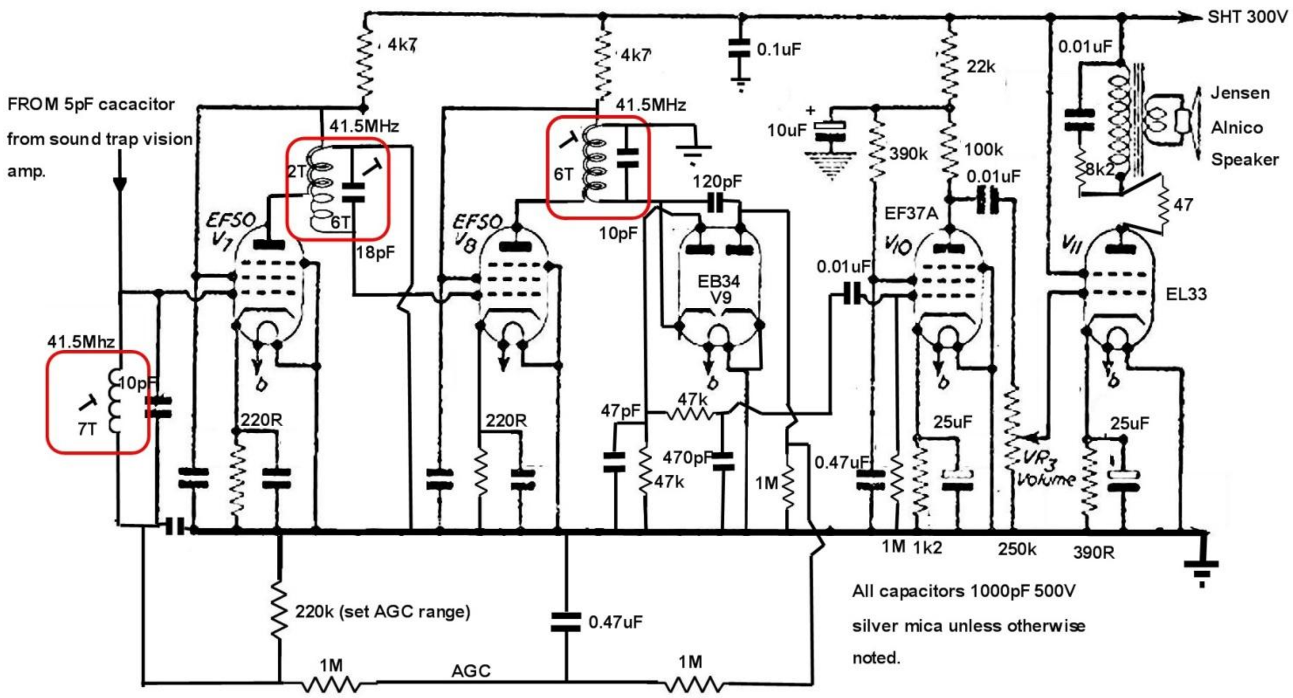
All of these measures noted above including the 250uH series peaking coil improve the upper frequency response of the video output stage. In this altered design the cathode signal from the phase splitter is not used, but it would be a good low impedance source to acquire an external video signal. Apart from these improvements, the overall circuit is still very much like the original Argus.

The contrast control adjusts the gain of the first two EF50’s.

Sound Receiver:

Basically I kept a similar design to the Argus, revolving around two EF50’s and an EB34. However, rather than using half of the EB34 as a noise limiter I decided it would be better to have an AGC around the sound RF circuits and eliminate the need for VR2, the sound sensitivity potentiometer. Also I used an EF36 or EF37A (rather than EF39) as the 1st audio amplifier and an EL33 (rather than 6V6) as the output tube. The speaker is a new Jensen Alnico magnet speaker. Again bifilar coils were used.

The circuit is with AGC added is shown below:



MY ARGUS SOUND CHANNEL. H. Holden 2016.

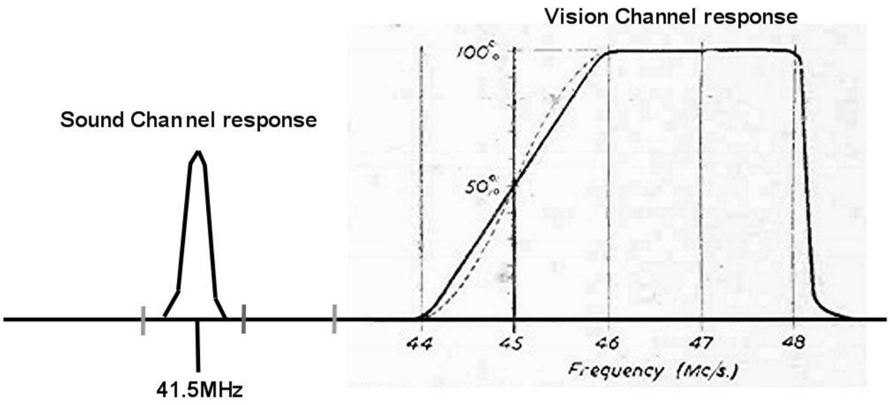
Adjusting the Vision Receiver's Stagger Tuned Coils:

One thing that surprised me is that there was little if any information in the Argus article series on how to correctly tune the vision amplifier, even though this is critical in obtaining a good quality picture, although general information on vision amplifier tuning appeared in other P.T. issues.

The original Alexandra Palace transmitter, transmitting on 41.5MHz sound and 45MHz vision carrier transmitted a double sideband (DSB) vision signal.

This meant that the band-pass response in the vision amplifiers could receive ***either*** of the sidebands or both. For example, the vision amplifier could be tuned to have a 50% response at the vision carrier signal and an increasing response ***above*** the carrier toward 48MHz. This scenario means that the responses of the sound and vision amplifiers to the sound and vision carrier frequencies were so far apart that sound in vision, or vision in sound, cross modulation or interference was unlikely.

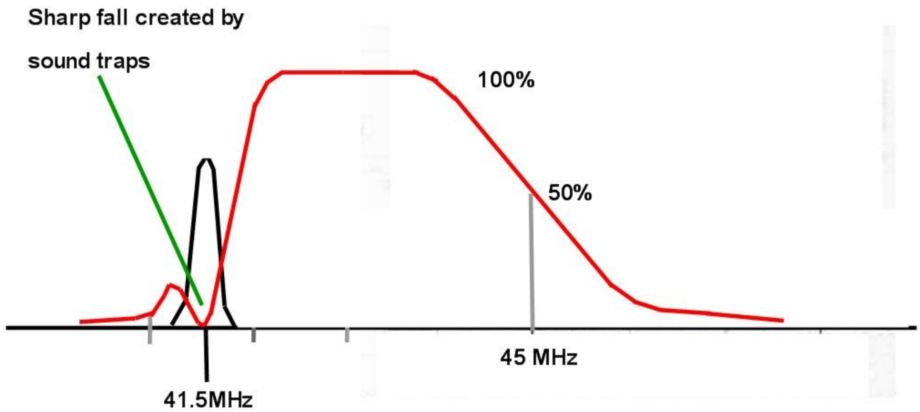
The graph shown below (with the sound channel response added) was the *theoretical* amplitude response suggested in P.T. in Jan. 1951 for a vision amplifier:



(Of note though, the *theoretical* vision amplifier bandwidth shown above cannot be used if any of the vision amplifier stages are shared with the sound, as they are in the Argus, where the first stage is common to both sound and vision).

On the other hand, the Vestigial Sideband System (VSB) was invented to save power at the transmitter and save bandwidth and allow more adjacent channels. All of the intelligence (modulation content) is in one sideband alone. Vestigial sideband transmissions followed later from other English TV stations. In this system the transmitter's upper sideband is suppressed and *the receiver must be tuned to the lower sideband*.

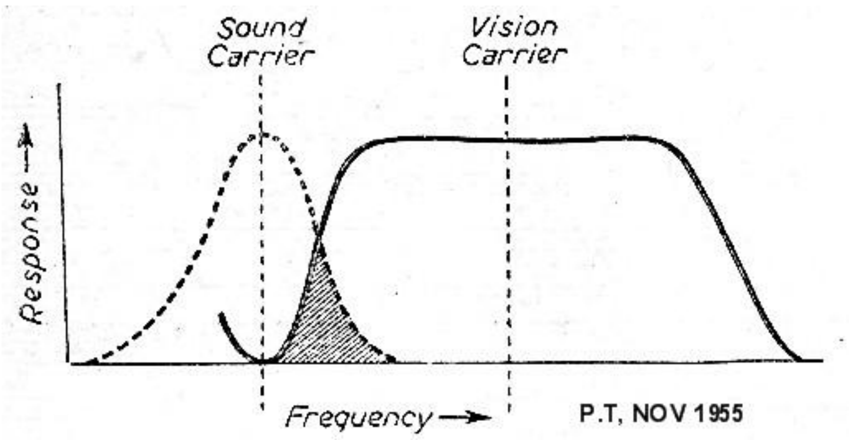
Therefore, in the VSB system, the receiver's vision channel frequency response is made to increase ***below*** the 45 MHz vision carrier frequency. However, especially in the context of the fact that the UK's sound and vision channels were, in the early days, only 3.5MHz apart (not 4.5 or 5.5 or 6MHz as in the American and later TV systems), then this vision amplifier response encroaches to some extent, even with sound traps added, over the 41.5MHz sound carrier frequency. The diagram below (in red) shows a vision amplifier's amplitude response across the frequency range when set up for 45Mhz VSB:



In practice though, with the VSB tuning, a perfectly sharp fall in the vision amplifier response is difficult to create with the sound traps. Therefore the bandwidth becomes a little more limited using this system because there is only a 3.5MHz spacing between the sound and vision carriers. Also the trapping is never perfect at reducing the vision amplifier's response (at the sound carrier frequency) completely to zero, so sound signals are more likely to modulate the video signal and affect the CRT's image. Also the audio is susceptible to "buzz" from video signal content, especially on peak whites in the image.

Later in the VSB system, the response of the vision amplifier, typically an IF amplifier, was deliberately left to be about 5% at the sound carrier frequency. This enabled a heterodyne of the sound and vision carriers at the video detector. This could be picked off with a trap. Typically a 4.5MHz sound trap in the American system and amplified through a separate 4.5MHz intermediate frequency amplifier, then on to a Ratio Detector. In the post war period in the USA they had already gone to FM sound and that system is called "inter-carrier sound" which became world industry standard for analogue TV.

Later again in November 1955 in P.T. there was a discussion on the ideal overall response curve for a "typical receiver":



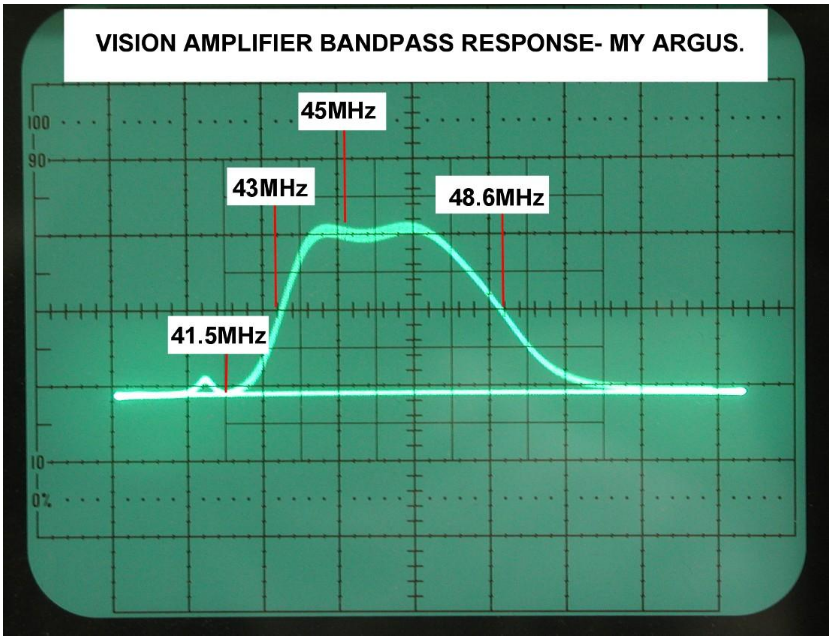
In this case they are making use of both the sidebands (assuming a DSB signal is transmitted) and they also made the remark:

"In practice the problem (sound & vision signal interference) is further facilitated by reducing slightly the response toward the low frequency side of the vision curve - this normally falls off between 2.0 and 2.5Mc/s (below the vision carrier frequency) without seriously detracting from the quality of the picture"

Since I have a 405 line standards converter with an RF modulator that produces a DSB signal, just like the original Alexandra Palace transmitter, I decided I could tune the vision amplifier in My Argus for either scenario (DSB or VSB) or any variation of response in between.

It is always a compromise between bandwidth and overall gain (gain-bandwidth product being a constant). Also, due to the fact the first stage of the vision channel amplifier is common to the sound, then it requires that the antenna input transformer needs to be tuned part way between the sound and vision frequencies.

The vision amplifier overall response is notched out to near zero by the two sound traps in my circuit at exactly 41.5MHz. The first trap is used to recover the sound carrier. The second trap helps to eliminate any remaining response at the sound carrier frequency in the vision amplifier output. No sound in vision modulation is detected with this arrangement and the picture is completely free of sound interference. The profile chosen tunes the receiver predominantly to receive the upper sideband:



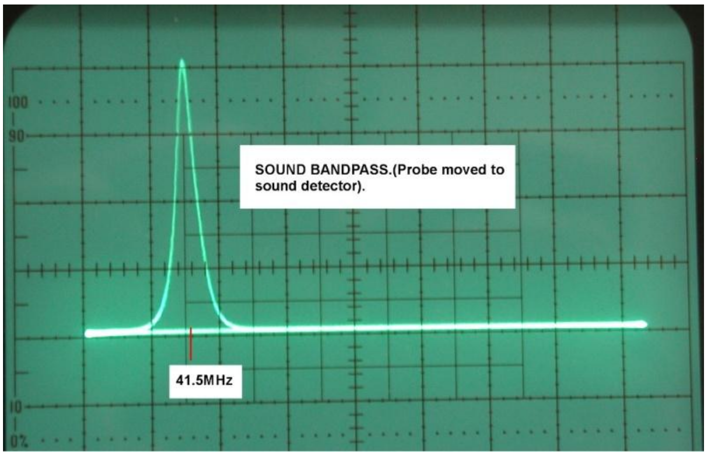
The photo of the scope screen above shows the tuning I settled on (using a sweep generator) for the vision amplifiers as seen at the video detector. With this tuning the video detail is satisfactory for the CRT size and the gain is very satisfactory and a video signal of 20V PP can still be obtained with an input RF level of 400uV peak but with some noise seen in the video signal.

In practice a 1mV peak RF input signal is ideal and the video signal is apparently noise free.

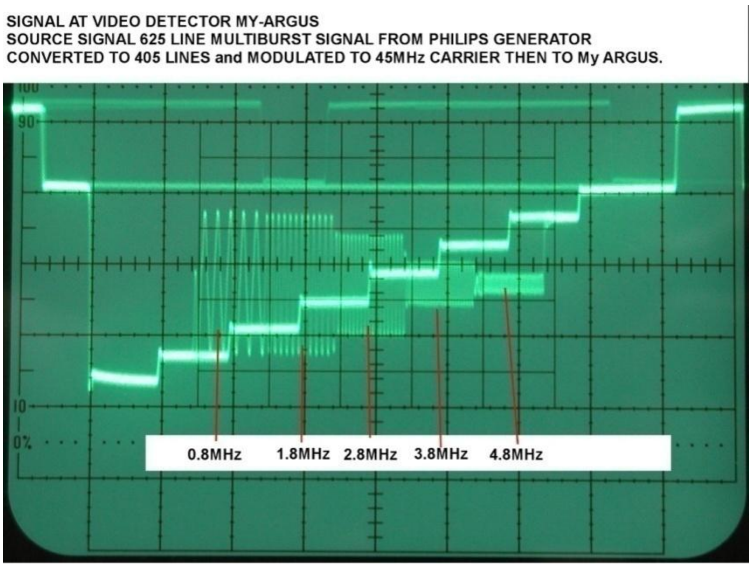
The EF50 video output stage can give 50 to 60V pp signal prior to clipping for a 1mV peak input level at the antenna). Also the tuning is adjusted so the shape of the characteristic doesn't change greatly with alterations of the contrast control which affects the gain of the first two EF50's.

***Note**: Tuning the vision amplifiers properly always requires a sweep generator attached to the antenna input & oscilloscope monitoring the video detector or video output stage. Guessing at the tuning by looking at the picture won't work properly and if the tuning slugs* *are simply peaked the bandwidth is too narrow and gain too high. If there is excessive response in the vision amplifier at the sound carrier frequency there will be sound modulation in the picture. There is no shortcut here. (Although the sound stages and sound traps can be peaked on the audio signal it is still better to use the sweep generator here too).*

The image below shows the sound sweep measured at the EB34 sound detector simply by leaving the sweep setup exactly as it was and shifting the scope probe from the video detector to the audio detector:

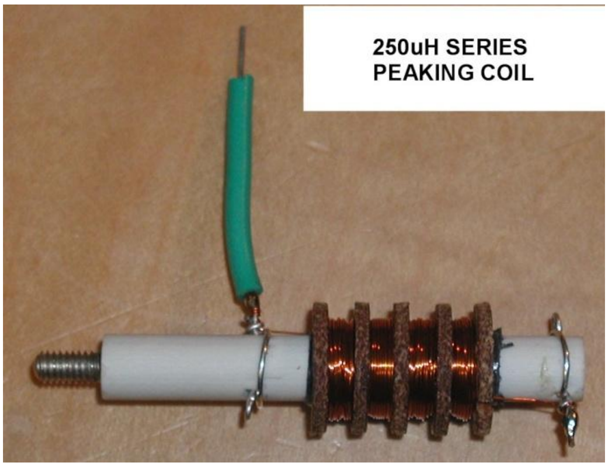


The scope image below shows the video at the video detector for a line of video on My Argus. The signal is derived from a 625 to 405 standards converter with 41.5 & 45MHz RF modulators feeding the set's antenna input. As can be seen the video frequency response tapers off, some off this is occurring in the standards converter as when it is fed from a 625 line multi-burst signal, the video output on 3.8 and 4.8MHz is very low after conversion:



The labelled frequencies are those of the 625 line signal from a Philips pattern generator ***prior*** to 405 line conversion, the actual signal above shown on the scope screen at the video detector is the converted 405 line version of the signal so the frequencies have been shifted after the conversion but it interesting to what happens to their relative amplitudes.

As noted above, the frequency response of the video amplifier in My Argus has been improved with series peaking. The picture below shows the series peaking coil which was added to the design of the video output amplifier:



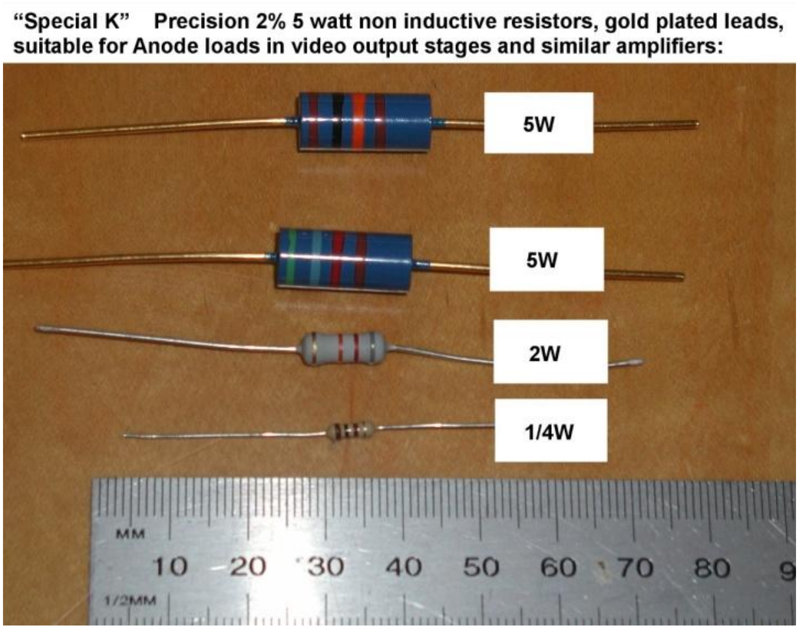
It was wound on a ¼" diameter ceramic coil form with partitions which help reduce the coil's self capacitance. There are 65 turns per bay or, 260 turns total of 0.22mm diameter wire.

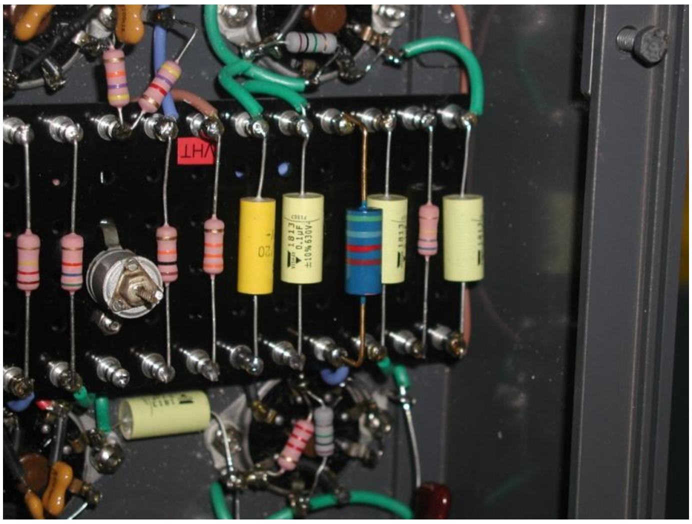
"Special K"

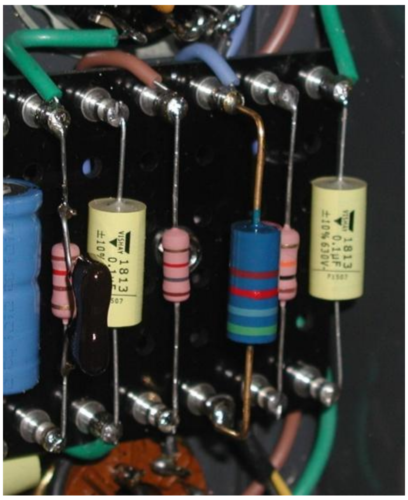
All resistors were not born equal, especially when it comes to certain applications. These applications include the ability to withstand high voltages without failure or alteration in the resistor value over time. Other properties include resistor noise; for example metal film resistors are better than carbon resistors in this respect. Another demanding application is the load resistor used in a video output stage. The resistor might have a value such as 5k to 10k and withstand 50 to 150 volts drop. The power dissipation could be as much as 4 watts. By the same token the resistor also needs to be a completely non inductive type, wire wound types cannot be used. Large size and higher power range quality carbon resistors are now usually a thing of the past.

Initially when I built My Argus I used two 10k resistors in parallel as the 5K load resistors for the video output stage and phase splitter stage. A larger value resistor gives more gain but a poorer frequency response. In some of their sets RCA went as low as 3k for the video output stage anode resistor. On some older sets it can be as high as 12k. In the Argus neither of these load resistors (if 5k6 in value) drops greatly over 100 volts and 2 watt resistors could possibly suffice however it always pays to use over-rated parts to improve longevity and long term heat damage.

I was able to acquire from Japan some excellent 5.6k 2% 5W non inductive resistors. The photo below shows the size comparison with other resistors. These were fitted to my Argus instead of the pairs of 10K resistors I first started with.







A note on tuning up the video output stage:

The idea of shunt peaking or series peaking is to add inductance to the output stage to help counter the effect of loading capacitance of the tube's plate, wiring, components and CRT grid. Capacitance causes a roll off at the high frequency end. If the inductor/s are chosen correctly, they will resonate with the capacity and increase the output at the high frequency end. Both shunt and series peaking work, series peaking is very simple and effective. It is very easy to find the correct value of inductance for series peaking experimentally. It involves coupling very loosely to the CRT's grid, with a 10k resistor wire lead wrapped once around the insulation of the hook-up wire leading to the CRT grid. This creates a very low "fraction of a pF gimmick capacitor" isolated further by the 10k resistance, so as not to add capacity or load the CRT's grid with the scope probe to any significance. The scope probe connects to the other end of the 10k resistor. Then with a variable inductor in place it is adjusted to peak the amplitude on a received multi-burst signal, in this case at around 3MHz or the upper desired frequency of the video signal. The inductor value is then measured on a meter and replaced with a fixed inductor. If the tuning peak is too sharp at the desired frequency then damping resistor such as 22k can be placed in parallel with the inductor to lower the peak and spread it out.

A cathode resistor bypass capacitor, for the video output stage, in the range of 1000 to 2700pF (depending on the cathode resistor value) is also helpful. The capacitor value is selected with the scope's x 10 probe connected directly to the video output feed but placing a 470k resistor in series with the wire to the CRT grid so as to isolate its capacitance. The capacitor value is selected to give square edges on the sync pulses without significant overshoot. (The x 10 scope probe's capacitance is similar to the CRT's grid capacitance and the former takes the place of the latter during this selection process).

CRT EHT Supply Used in MY ARGUS:

An interesting question about the Argus and the VCR97 could be: What was the exact intended EHT voltage?

There was little data about the high voltage transformer in the Argus articles. However in P.T.'s Febuary 1953 issue, on page 405, it was stated, for the Argus, that the voltage from the transformer was 2500V and from the HT was 450V making the total EHT supply for the VCR97 CRT close to 3000V. However most likely the typical total voltage was around 2450V because most of the hobby EHT transformers combined with the 2X2 rectifier and filter capacitors appear to have provided about 2kV at the time.

The internal base assembly/wiring on a VCR97 CRT can just support 3kV when it is clean and the insulation is good, but 2500V is less likely to be problematic than 3kV. Also if the EHT is too high the deflection voltage requirements are proportionally higher.

(Of note the amount of deflection in electrostatic cathode ray tubes is inversely proportional to the EHT voltage, so if the EHT is doubled, then twice the defection voltage is required for the same width & height picture. On the other hand for magnetic deflection the deflection is inversely proportional to the square root of the EHT, so if the EHT is doubled it requires an increase of only 1.41 in deflection current to get back to a picture of the same size. This of course was one of the many reasons why ultimately electromagnetic deflection was to win out over electrostatic deflection, especially for larger sized picture tubes).

The EHT transformer for My Argus posed an interesting problem. Mains to 2kV or thereabouts transformers are not very common these days, especially ones with low voltage well insulated secondary windings to power the filaments of EHT rectifiers such as the 2X2. Some solutions outlined in P.T. involved the use of voltage multipliers from the main power transformer, solid state rectifiers or 6H6's in Cockcroft-Walton style voltage multiplier circuits.

It is difficult to wind and properly insulate a very high voltage winding with fine gauge wire and to make it "failure resistant".

One solution to get the EHT is to use a pre-made semiconductor high voltage module, such as those made by Emco, however this would not be period correct and somewhat anachronistic. Also then the original 2X2 classic high voltage rectifier would have no application.

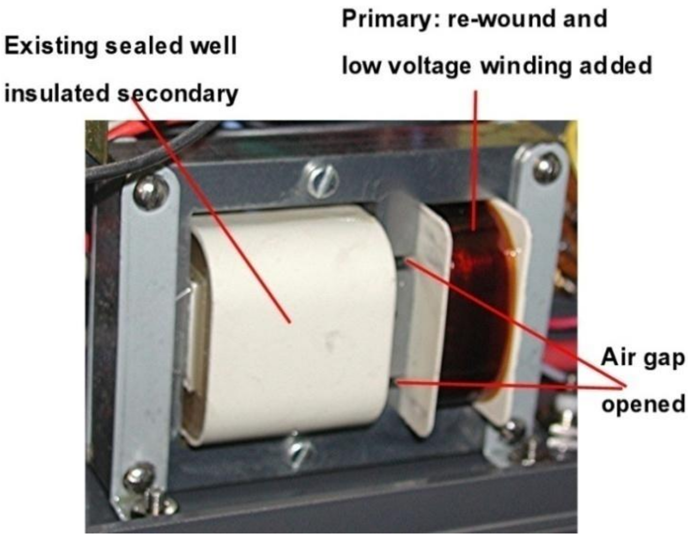
There is a type of small transformer used to run neon signs with a 3.6kV secondary. The beauty of these is that the primary and secondary bobbins are independent. So the transformer can be disassembled and the primary can be re-wound to get the correct secondary voltage and a well insulated 2.5V secondary can be added to that bobbin to power a 2X2 rectifier heater. Moreover, the secondary high voltage winding is perfectly layer wound with insulation between each layer (like an old fashioned transformer) but the winding assembly is also vacuum impregnated and sealed with fibreglass resin and further insulated inside an external former, making it super reliable and not prone to failure.

One curio is that these neon sign transformers have a partly closed *magnetic circuit* around the primary bobbin with a narrow air gap. This has a number of effects including lowering the *rms* voltage with respect to the peak voltage value (due to waveform distortion). Also this design feature decreases the magnetic coupling to the secondary and allows the peak voltage to be high to "strike the neon tube" but drop off under load when running the tube. However this is an undesirable property for this TV application because it decreases the voltage regulation.

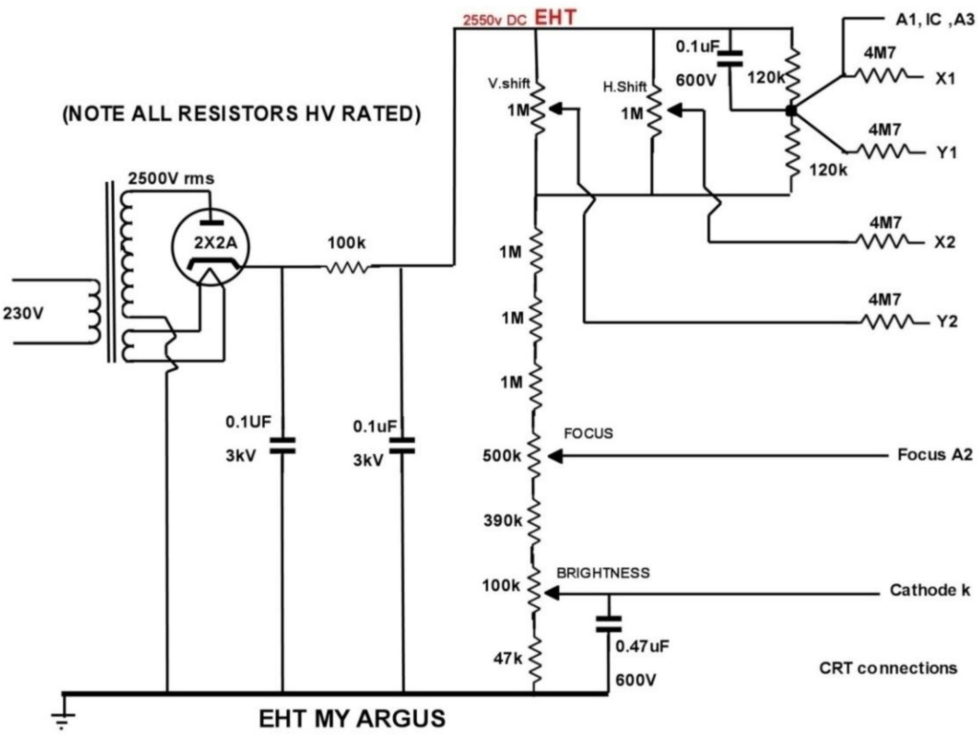
Therefore, the magnetic circuit needs to be opened by removing 3mm of lamination material from the central lamination stack, from every lamination, to open this air gap on each side. I found, with the transformer disassembled that I could simply saw this off all the central laminations, all at once, with a junior saw and file them smooth and lacquer the cut surface.

The primary bobbin was rewound with 2800 turns of 36 awg wire and the 2.5V secondary (on the primary bobbin) wound with 37 turns of 0.8 mm diameter wire and insulated with polyamide tape and polypropylene insulation to make it safe to at least 3.5kV. This creates a transformer with close to a 2600V *rms* output and 2.5V output (under load) when run from 235V on the primary.

It turns out that after rectification and smoothing in this system with the 2X2, the DC output voltage is similar to the transformer's *rms* voltage. In My Argus with a standard negative ground the EHT measured, with a precision probe, is close to 2600V for a 235v mains supply. The modified transformer is shown below:

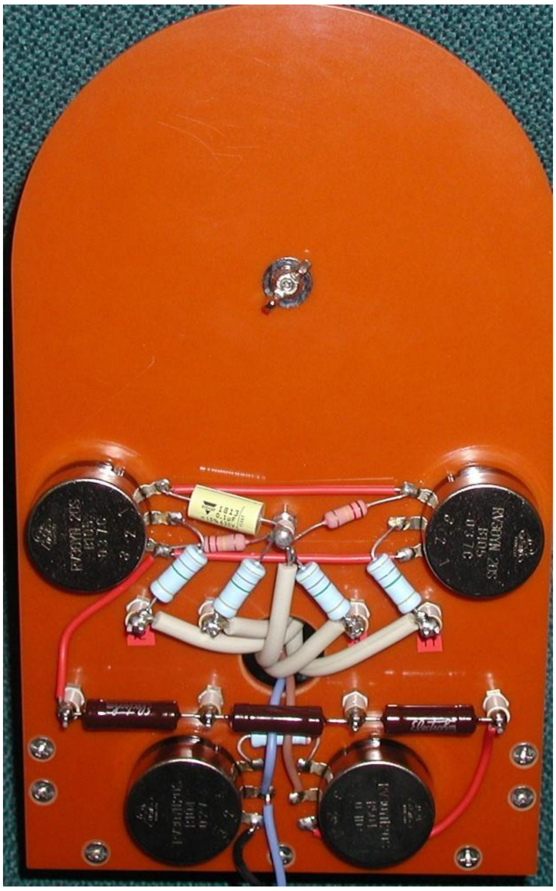


The EHT circuit for My Argus is shown below. The 0.1uF 3kV filter capacitors are Russian made PIO (paper in oil) types that resemble classic looking capacitors of the 1950's era.



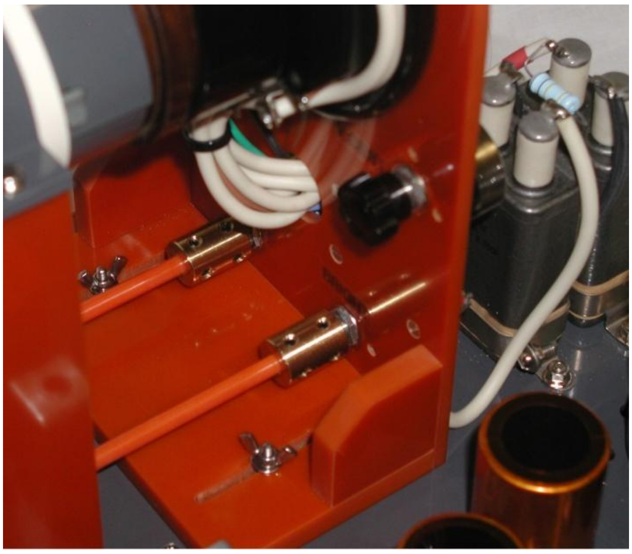
For the CRT's circuitry, it is important the resistors are high voltage (1000v) rated or more. The assembly for the EHT system was created with high voltage Philips "focus resistors" and the high voltage 1Meg resistors are made by Electrohm. Quality 2W rated Cosmos (Japanese) potentiometers were used. Standard voltage rated resistors are not suitable for the main divider chain and fail with high voltages, especially the 1 Meg resistors.

The whole CRT EHT assembly/circuit, unlike the original Argus design, is fitted to the rear CRT support. This support was made of phenolic material rather than metal. The phenolic material was purchased in Akihabara (Japan). The photos of this assembly are shown below:



The dark red picture centring control knobs above were temporary. Later they were replaced with Bulgin knobs like the ones used on the front panel. The panels to make this CRT stand were precision CNC machined to external shape/perimeter sizes and the edges smoothed and holes & threads made manually. The phenolic coupling rods for the focus and brightness controls are the same phenolic material, also sourced in Akihabara. The original spacing of the rods (and front panel controls) for the Argus was 1.5 inches. This was increases to 2 inches for My Argus.

The chassis rear has a mains power IEC filtered connector assembly, a mains on-off switch, a mains fuse and a 75 Ohm antenna input connector.



Main Power Supply Circuit:

My Argus is powered via a Hammond 378X transformer. This is a universal mains voltage input transformer. Hammond universal transformers have *very low* primary magnetisation currents on both 60 and 50Hz and little stray radiated 50Hz magnetic fields. Many vintage mains power transformers, especially 60Hz types have terribly high magnetisation currents when run on 50 Hz and high range radiated magnetic fields which disturb a CRT's beam even 3 to 4 feet away. On the other hand the Hammond transformer very suitable for any CRT based equipments. In addition Hammond smoothing chokes were used. An auxiliary transformer (RS brand) was also added to power the heater of the VCR97 and three of the SP61 tubes, in order that the 6.3V @ 6A winding on the Hammond 378x was not overloaded.

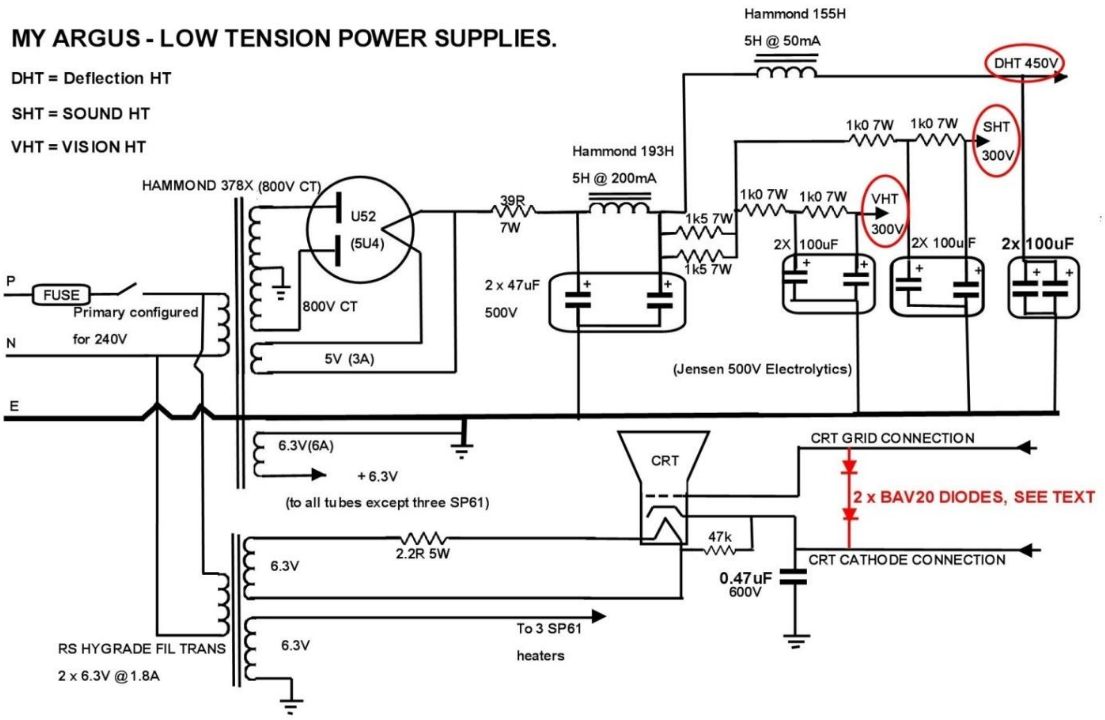
As noted in the circuit below, high grade Jensen Electrolytic capacitors were used with plenty of capacitance so there is no hum or power supply ripple issues in this set. Due to the relatively high input capacitance (47uF) for the 5U4 output, a 39R resistor was included in series, to ensure the overall plate supply resistance was not too low and peak plate current not too high for the 5U4.

Note*: some GEC 5U4 (or U52 rectifiers) like the one on the photo above on the chassis are listed on Ebay for prices like 250 GBP now. The better solution is to buy a Ruby brand 5U4 (supplied by Magic Parts) which is electrically identical in every way and just as reliable as the vintage GEC & Mullard tubes. Normally a Ruby 5U4 tube sells NOS for around 20 GBP* *or less which is a much more sensible and realistic option. I've tested the Ruby 5U4's in my laboratory and they are every bit as good or better in many cases than any vintage 5U4 version. They are really a direct well made clone of RCA's original part.*

Also as noted below, two diodes BAV20 or 1N458A's, are placed across the grid-cathode of the VCR97. It is very important for a CRT that the grid is not allowed to be driven positive with respect to the cathode at any time. These two high voltage rated very low capacitance diodes prevent that. So although not "period correct" it is better to protect the vintage CRT from damage in the event of a fault developing by adding these two diodes.

Since there is quite a different voltage requirement (450v for the deflection HT, but only 300V or less for the sound and vision HT) it requires dropping resistors with significant heat dissipation, about 13W in total. So I decided to spread that around on a total of six robust 7W rated axial wire wound resistors to avoid too much heat in one locality or one resistor.

Later the two parallel 1k5 7W resistors were replaced with a single 1k 20W tubular ceramic mounted on heat proof washers:



MY ARGUS Mechanical Construction, Wiring, Components and Tag Boards:

The main deviation away from the original Argus design was to avoid the separate sub-chassis and the unshielded RF coils. In the original it required cumbersome shield plates between the EF50 stages. It is much better to have the coils in shielded enclosures (Aladdin type) and go for a single chassis.

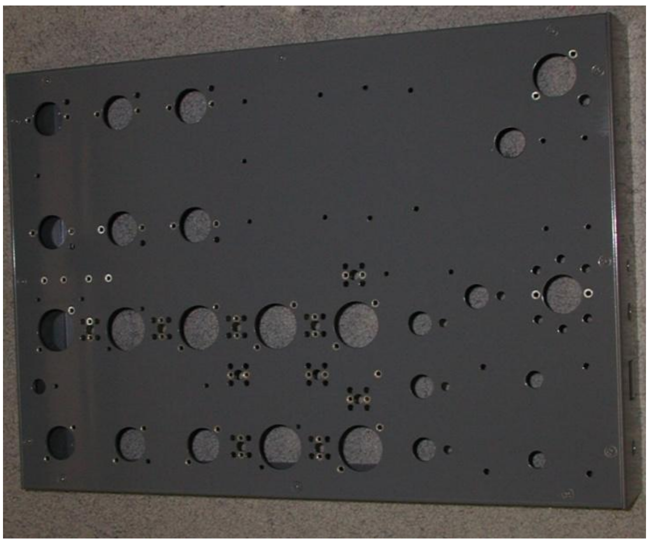
The chassis for My Argus was fabricated from 1/8" thick aluminium and the sides are extruded 1/8" thick aluminium channel. It has a 1/8 inch thick top chassis plate and a perforated (ventilated) 1/8 inch thick bottom plate. This makes a super rigid structure that does not flex even with the very heavy Hammond 378X transformer. The front panel is also 1/8 inch thick. The assembly screws pass into hard internal metal corner brackets, not aluminium. This is a great feature.

This chassis was CNC machined for me by Landfall Systems LLC. I received the chassis kit bare. I treated with Alodine and painted it with VHT machinery grey spray paint after masking the holes with pre made 6mm diameter disc stickers (made by Stickerman) where the earth points are important.

A Plug for Landfall Systems:

Landfall Systems, LLC (Texas USA) can supply CNC machined chassis, anodised and with other finishes. Of note Landfall also manufactured the front panel with the precision large round holes for the CRT and speaker and even the tube face surround that has an internal taper to match the tube's rubber escutcheon. Landfall did a fantastic job on all of it. More often than not I'm disappointed by the quality of a job, if I farm out, but Landfall Systems have impressed and surprised me. They did the work promptly and for a very fair price and packed it perfectly for international transit. So I would recommend their service to anyone wanting an unbeatable quality super strong chassis with precision cut holes, for any project.

A photo of the chassis prior to construction is shown below. Note the arrays of precision machined holes including the " 7 hole arrays " for the Aladdin RF transformers and the ventilation holes around the 5U4's socket:

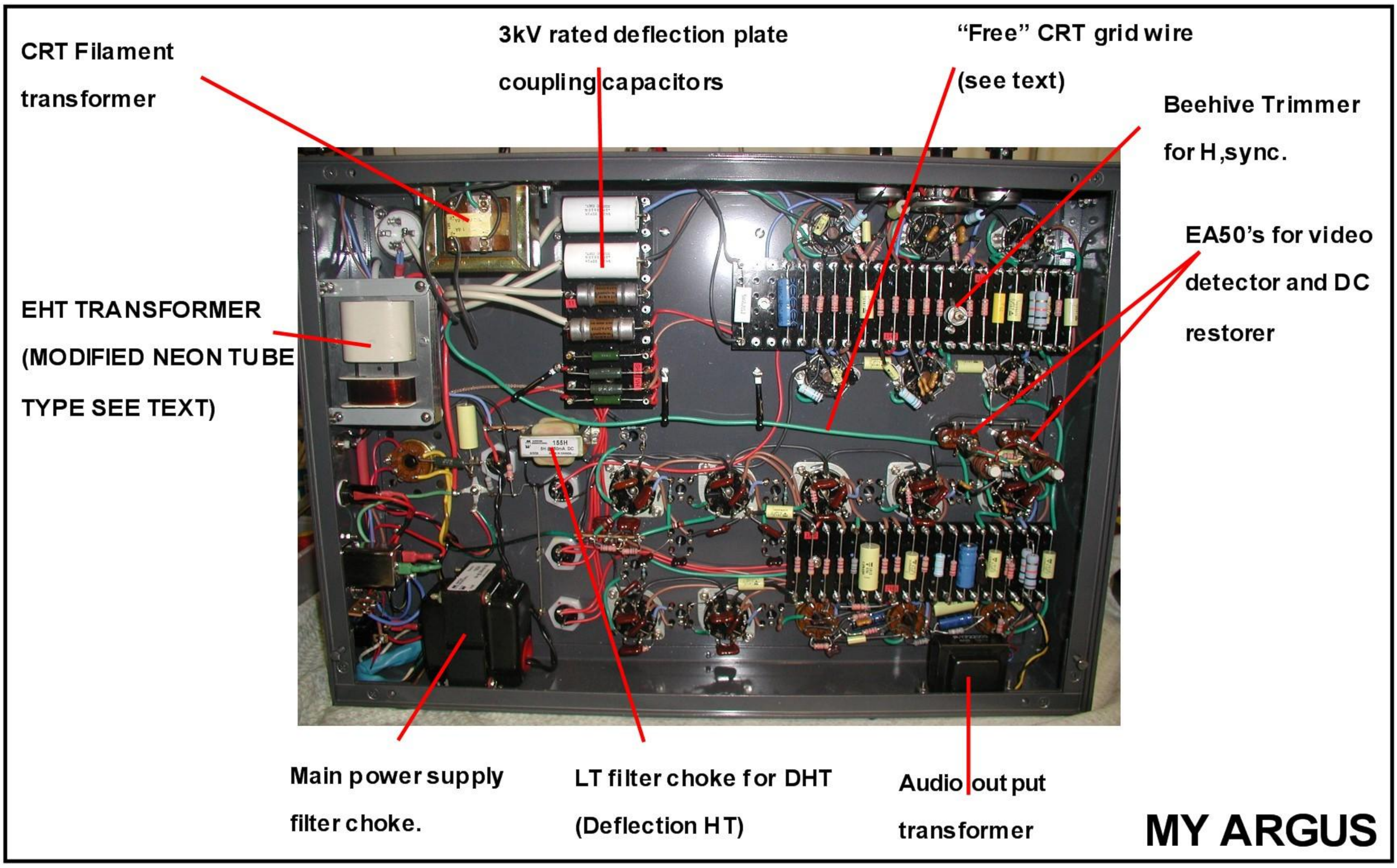


The hook-up wiring in this set is coloured (brown, blue red , black and green) temperature resistant harsh environment silicone rubber covered hook-up wire. It has an external diameter around 2.6mm and a great look and feel to it and resembles vintage rubber covered wire, but is far superior to that.

The black tag/turret boards are 3mm thick fibreglass and fitted to the chassis with stand-offs. These boards were fitted parallel with the chassis surface, rather than the perpendicular mounting in the original Argus for the deflection stages. Also a tag board was used to improve the layout in the sound and vision stages and to support the high voltage deflection plate coupling capacitors required in the changed circuit with conventional negative ground EHT.

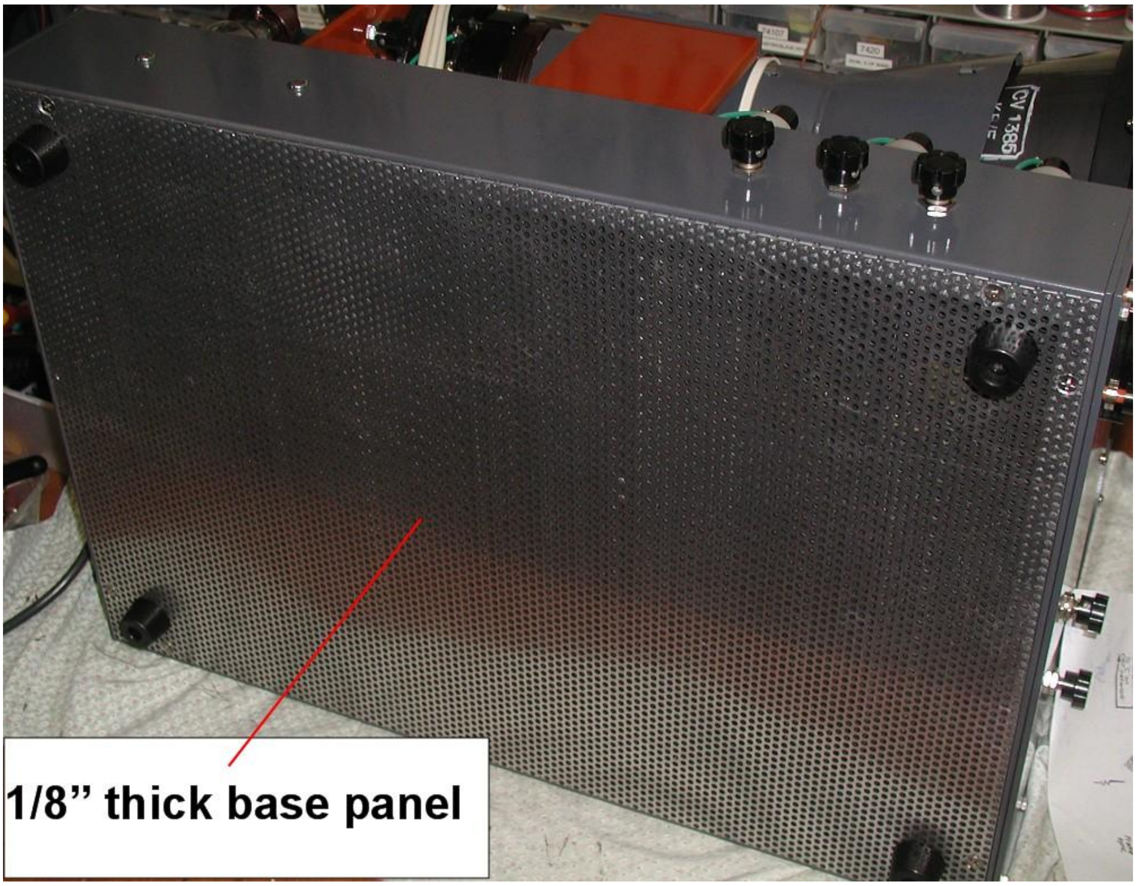
The hardware is 4 and 6 BA nickel plated brass, except for the transformer mounting bolts and front panel attachment bolts which are 8-32 stainless steel.

Nearly all the resistors are 2 watt metal film. Modern 2W resistors are about the same size as 1/4W ones from the 1950’s. All of the capacitors in RF applications are mil spec 500V silver mica types. The octal sockets are mil spec types and the EF50 sockets are wartime mil parts. As noted above, the grid wire feed to the CRT is kept suspended from the chassis and away from most other parts:

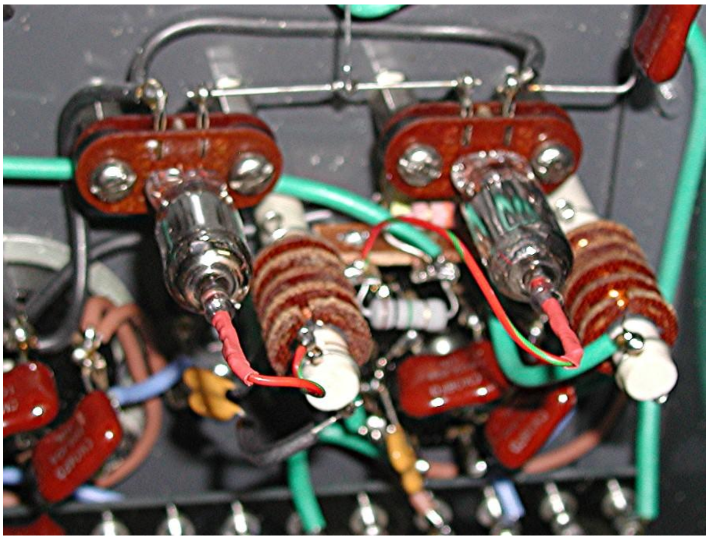


As can be seen there are threaded holes in the side extrusions which are in the solid metal internal corner brackets. These allow the 1/8 inch thick perforated chassis bottom to be attached.

The base (bottom) panel is a pre-perforated type. Because it is again 1/8” thick it easily supports the 4 hard plastic base feet. For this application they are better than rubber, due to the weight of the apparatus. The fixing screws pass into the internal metal corner brackets hiding inside the aluminium extrusions:

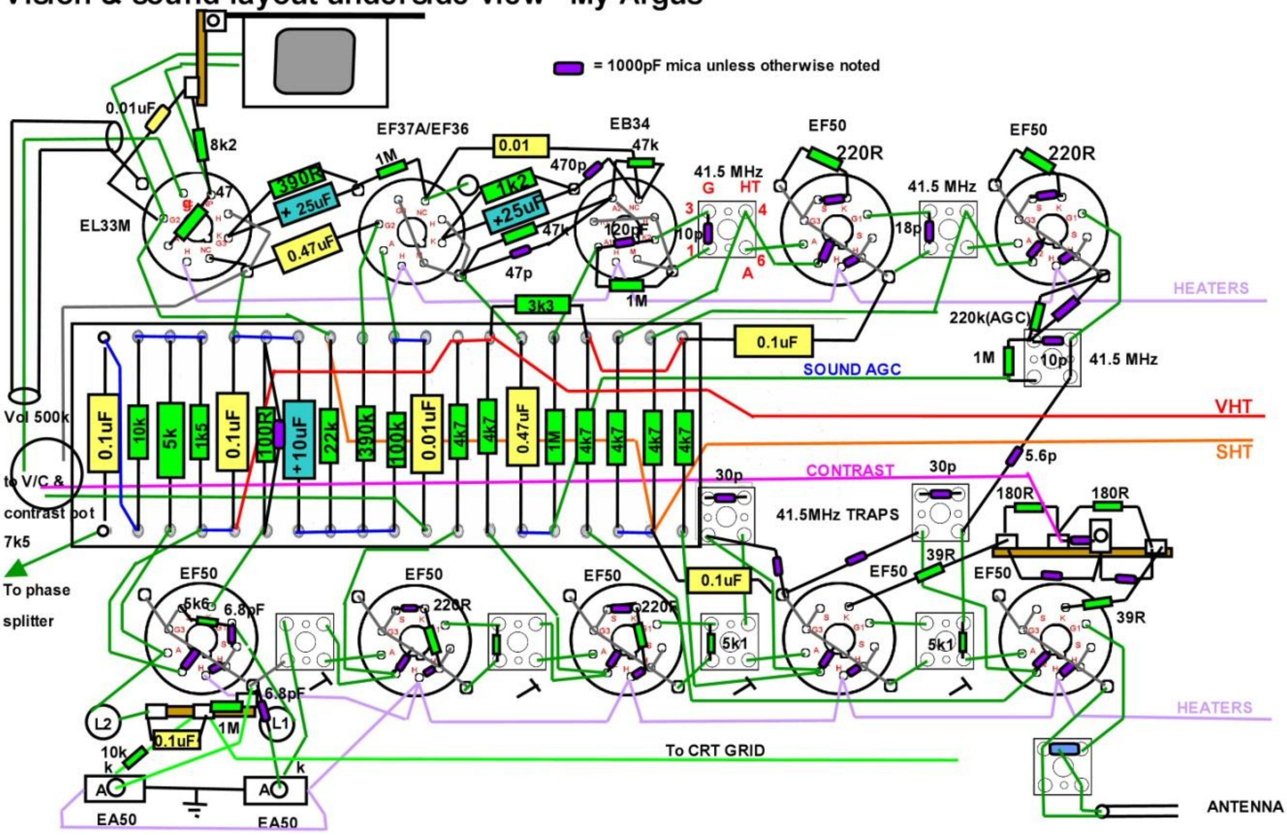


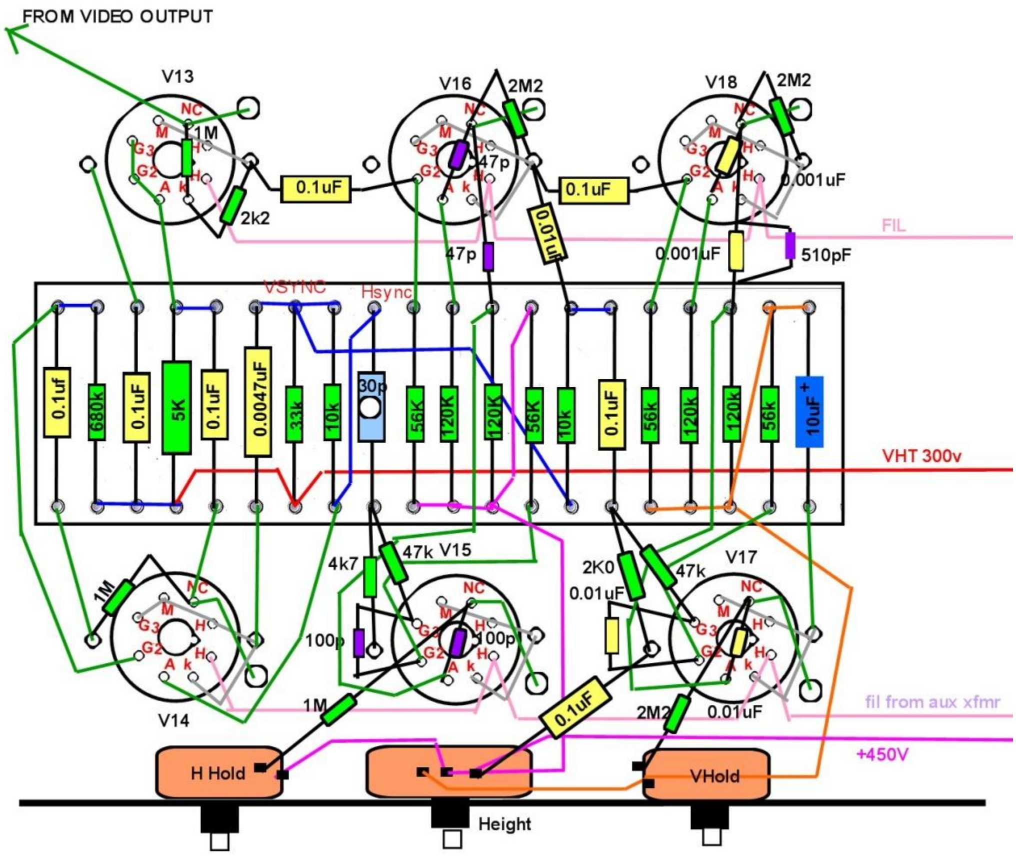
The photo below shows the area around the video detector and DC restorer where there are peaking coils wound on partitioned ceramic formers near the two EA50’s:



Finally, the actual wiring and component layout was pre-planned with a diagram. This helped to avoid any surprises cropping up in the construction. The diagrams I used for this are shown below and acted as the guide for component placement. This is quite different to P.T’s blueprint:

Vision & sound layout underside view “My Argus”





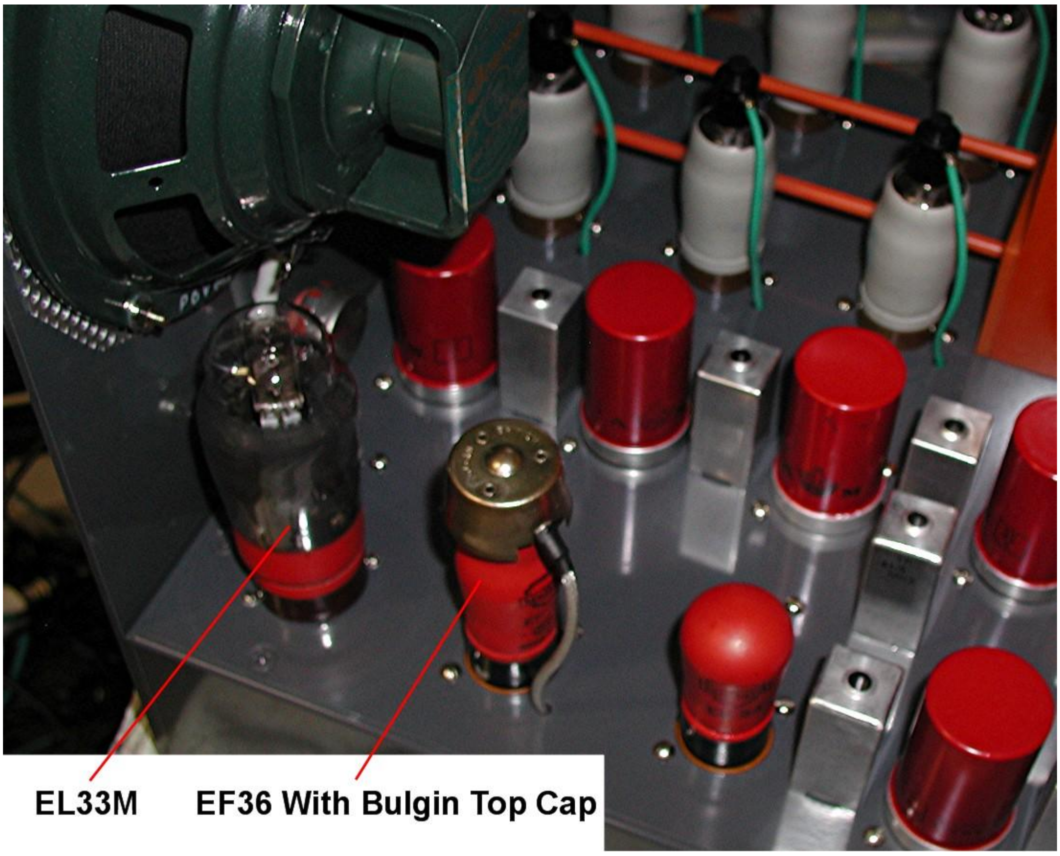
The 10uF capacitors are 450V rated and the 25uF capacitors were actually 22uF 160V types.

FINAL TOUCHES:

There was one component that was extremely difficult to obtain. A shielded top/grid cap for the EF36. These were made by Bulgin. I finally located one and fitted it to the set. All of the original Argus photos appear to show a similar cap. Also I realised the audio output tube, the EL33, also comes as an EL33M, with a flash of red conductive paint around the bulb, so I fitted one of those to the set.

Also the silver conductive paint on the SP61's was coated with a clear coat of VHT (high temperature enamel) to prevent this coating corroding. Many SP61 tubes now have severe surface corrosion with the *bare* metallisation in contact with corrugated cardboard in their storage boxes. Salts & moisture in the cardboard react with the bare metallic paint. Red painted metallised tubes did not suffer this fate to any great extent as the red paint protected the silver metallisation underneath.

The photo below shows the elusive and wonderful Bulgin shielded grid cap and the EL33M audio output tube:



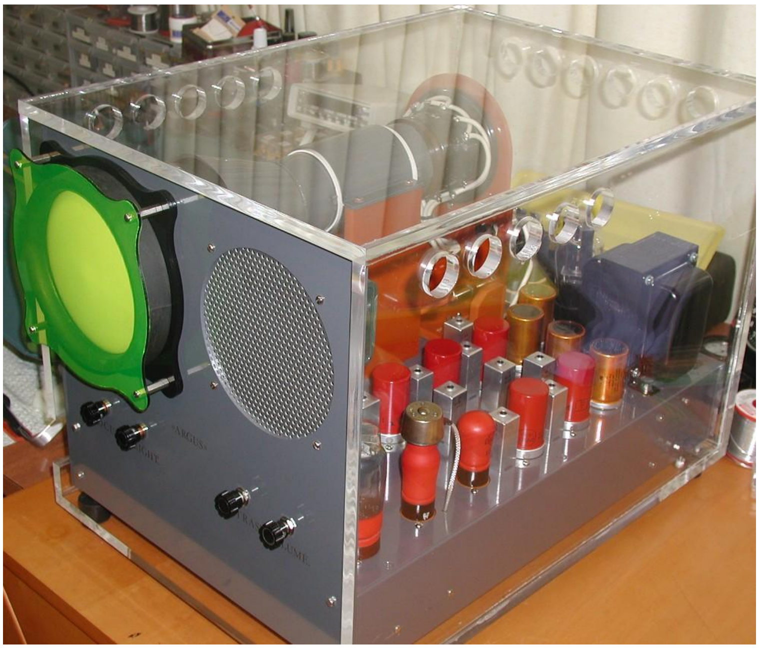
A good number of the tubes in this set and other parts were supplied by Langrex Supplies in the UK who supply excellent quality original tubes.

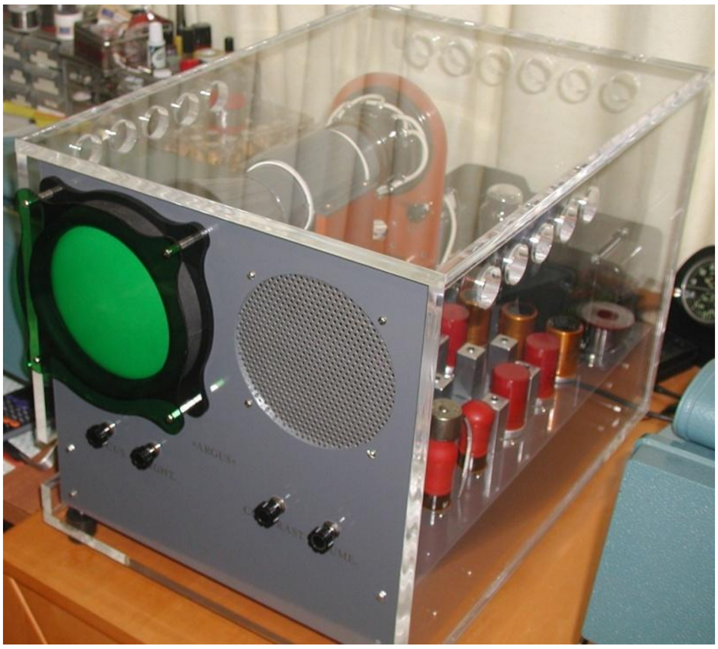
The option I went with for the audio pre-amplifier, which was an EF39 in the original Argus, is the EF36. These are a good audio tube and not as expensive as the EF37A.

Also, since this set has exposed 2.5kV connections on the CRT socket and nearby (just as the original Argus had) it can't really be safely operated around inexperienced observers in case of prying hands and fingers. So I'm in the process of making a solid plexiglass cabinet for it.

Nov. 2016 Update – Argus Case & Filters:

As noted, there are a few exposed high voltage contacts around the CRT. People are curious and reach out. So I decided to put my Argus in an acrylic enclosure. It is well ventilated with a large rectangular hole under the chassis, and quite a few round ventilation holes:





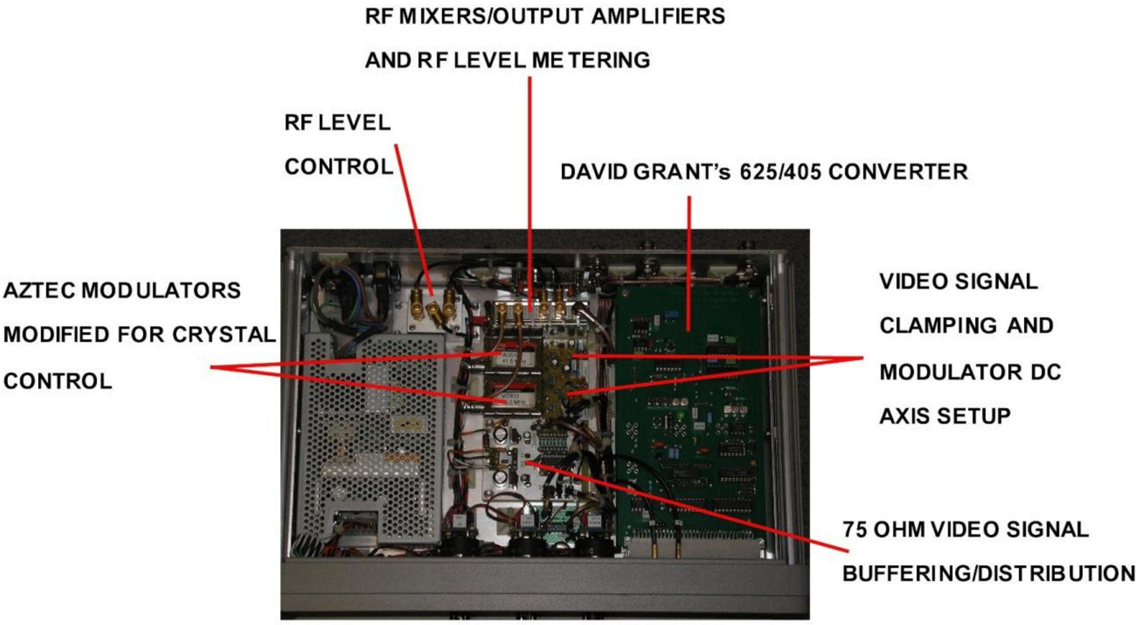
Also as can be seen I tried a range of screen filters. I acquired an original filter from a radar indicator which used a VCR97 as a reference. After trying a number of types of tinted acrylic, I found one with a slightly less dark tint that the original and a slightly more “leaf green” colour that appears to match the phosphor almost perfectly. Using the filter definitely improves the contrast ratio in a well lit room, and makes the picture viewable in bright room light. Without the filter the set ideally is viewed with subdued lighting. The picture below shows some of the filter materials I experimented with.

The Fluoro green wasn’t ideal and the filter needed its edges darkened, but the leaf green one in the middle didn’t. The round filter is the one from a radar indicator:

The photo below shows the unit running in bright room light. The Alexandra Palace transmitter has become a set top box:

405 LINE STANDARDS CONVERTER:

The photo below shows the insides of my standards converter based around David Grant's Dinosaur converter pcb's. To make it replicate the TV transmission signals from the original Alexandra Palace, RF modulators are required. These are Aztec units which I modified for crystal control so as to ensure stable frequencies of sound carrier 41.5MHz and vision carrier 45.0MHz.



"ALEXANDRA PALACE SIMULATOR"

Other circuitry is incorporated, including video signal buffering with a Max497 IC, RF mixing/amplification based on Mini Circuits AMP76 monolithic RF amplifiers built into RF shielded enclosures within the unit (connected by SMA connectors) and a Mini Circuits ZMAS3BR RF level controller. Also RF metering is done to make the unit function well and make it easy to use. Circuitry to clamp the DC axis of the video signal prior to the modulator is critical as this sets the residual carrier on full modulation for a fixed video drive voltage. RF metering is performed with the Avnet UTD1000 Analog level detector and an OP amp bridge meter drive circuit. The unit was built into a high quality Elma (Switzerland) case: