A technical overview of the AZ-58 Ray Tube Frequency Device

I have been involved with AZ-58 research since early 2000 after the schematics were released by Stanley Truman on his website http://www.rife.org/az58/az58.html , supplied by Jason Ringas of The Rife Research Group of Canada and subsequently corrected and tested by a broadcast engineer James R. Cunningham. Back then there was much speculation as to what the original Rife effect might have been, and the AZ-58 represented the best opportunity for experimentation. Today it serves as a reference design for this and even the Beam Ray's type of machines.

The aim of this report is as follows:

- Part 1
    - Brief History
    - To examine some of the circuit anomalies which are noted?
    - Examine the development history of the AZ-58
    - Discuss the original components that the AZ-58 was constructed from
    - Solve the remaining circuit anomalies so as to develop a clear baseline for building devices.
- Part 2
    - Simulate the various aspects of the circuit in LtSpice circuit simulation tools, to get a detailed understanding of the various circuit elements and how they operate.
    - Build and Measure a replica AZ-58 device
    - Establish a calibration baseline for the device.
    - Examine the spectral output of the system

Brief History

John Crane started his association with Royal Rife in 1950. His first order of business was to resurrect Dr Rife's ray tube instruments of which 6 were built in 1953. Due to problems manufacturing and matching helium filled ray tubes to the AZ-58 John Crane looked for an easier solution to bypass the ray tube, he came up with the square wave generator pad type device in 1959, which we now know was initially based on the EICON 377K kit frequency generator. He had success with the same set of frequencies that the AZ-58 used, and slowly the AZ-58 faded away, save for two newer device designed by John Marsh for his own personal use. In addition it turns out Vern Thompson, Dr Rifes engineer at the time was also building devices on the side.

1950 – Crane writes to Dr Grunner of Canada and obtains one of the original circuit diagrams this is redrafted by Crane dated 3-5-51 for Verne Thompson a radio man from the San Diego police force who had previously worked with Dr Rife is hired part time and 6 frequency instruments are built. The initial instruments were not effective, a Hewlett-Packard frequency counter was acquired and the instruments properly calibrated, the some improvement in patients was noted. New ray tubes were designed and built and some circuit changes were made. Several cures were affected for the first time.

Crane then made another discovery in the circuit which allows control of the intensity of the ray emission. This involved what he termed "a dual resonance balance". The balance of the carrier wave and the critical gas pressure gives proper emission. A weak ray yields poor results. Tuning capacitor added later **in 1954.**

In October 1957, Crane made a circuit change that allowed control of the intensity of the ray emission. “to make the colour intensity of the helium gas to be variable

Stafford is given an instrument in late fall of 1957 (July or November) by Marsh.

In spring 1958 an instrument was delivered to Dr Jeppson M.D. of the desert Medical Centre Salt Lake city.

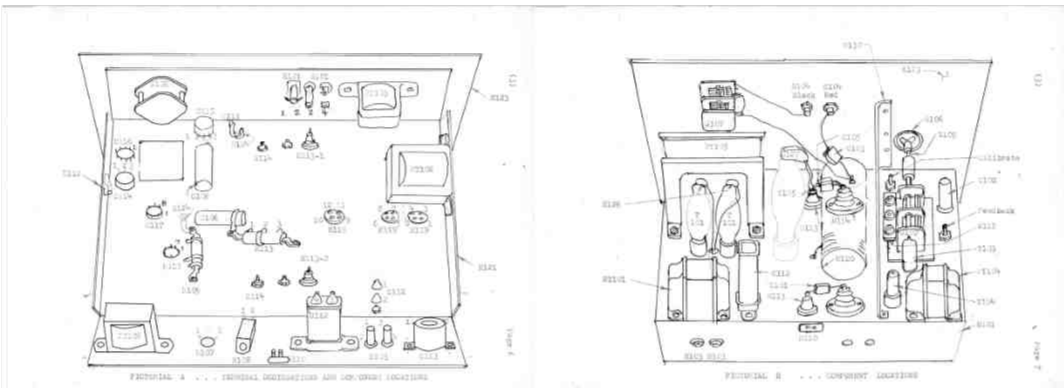
Due to difficulty in obtaining precision ray tubes and balancing thereof, further work was done to eliminate the ray tube completely. Crane decided to build instruments without a ray tube. 34 Model 1 instruments were built in 1960, some cures were noted.

- Stafford gets Rifes original data from Crane – 1957
- Stafford - Clinical and Laboratory Experiences 1957 – 1963
- Stafford 16 cases of Advanced, Terminal Malignancy – Failed to cure, however some improvements were noted. All treated wit (728-784-880-2008-2128) Protocol
- Stafford 16 cases of dermatological problems responded favourably to EFT
- 60 Cases in total treated

Original Diagrams

The following diagrams represent the source documents from which others have built devices. It is important to strip away and get down to original document level to completely understand the AZ-58. I have been privileged to see copies of the original AZ-58 “Notes on assembly and Wiring or the Frequency Instrument” courtesy of Jason Ringas. I was also fortunate to have collaborated with Robert Harrison at the time, just before he got involved with the British Rife Group and became bound by their confidentialities. It is interesting to note that the diagrams posted on Stan Trumans site have some minor detail removed!

We have two source schematics, one from John Crane from Allied Industries, and the other from John Crane’s 1973 patent application 830.587



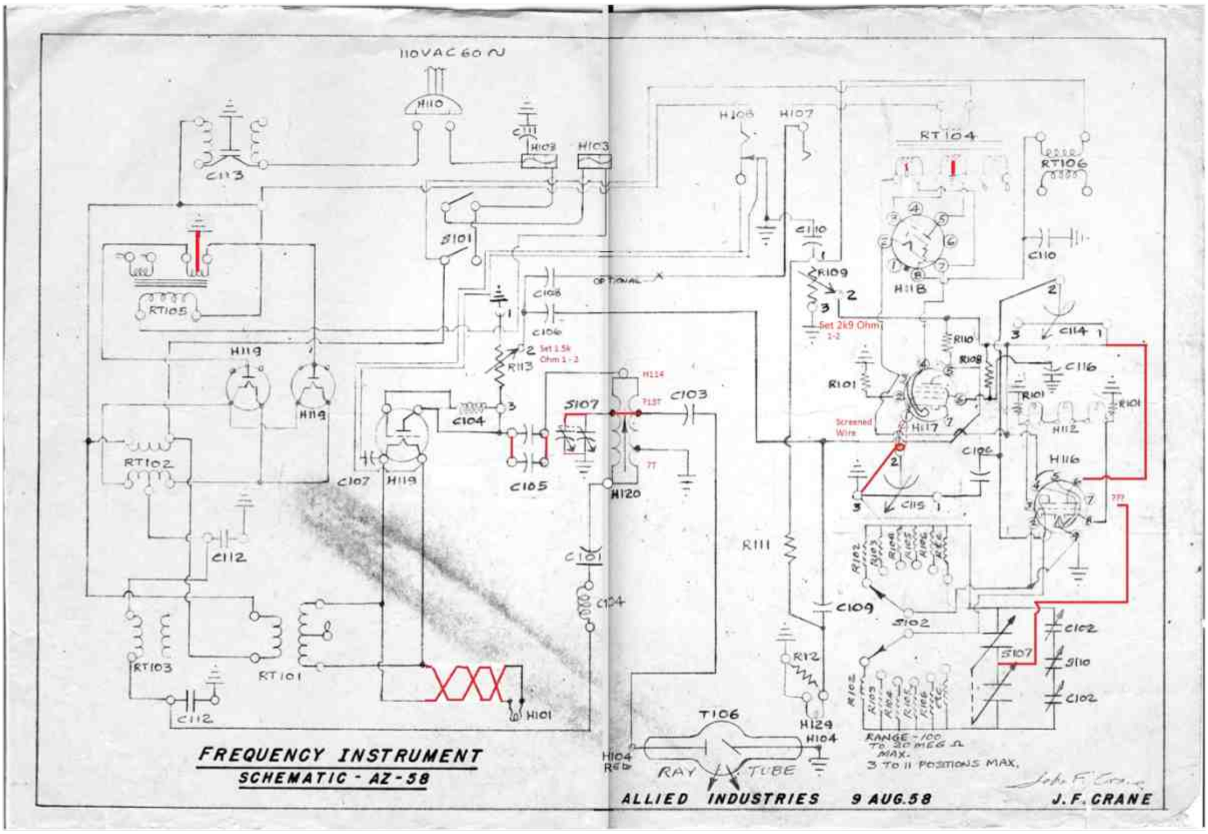


Figure 1 Allied Industries 1958 Schematic Diagram – Wiring Instruction Added – Pictorial C

The above drawing has had detail added from the "Notes on assembly and Wiring or the Frequency Instrument" however it is still incomplete.

The next diagram has errors highlighted in orange, and each error is discussed:

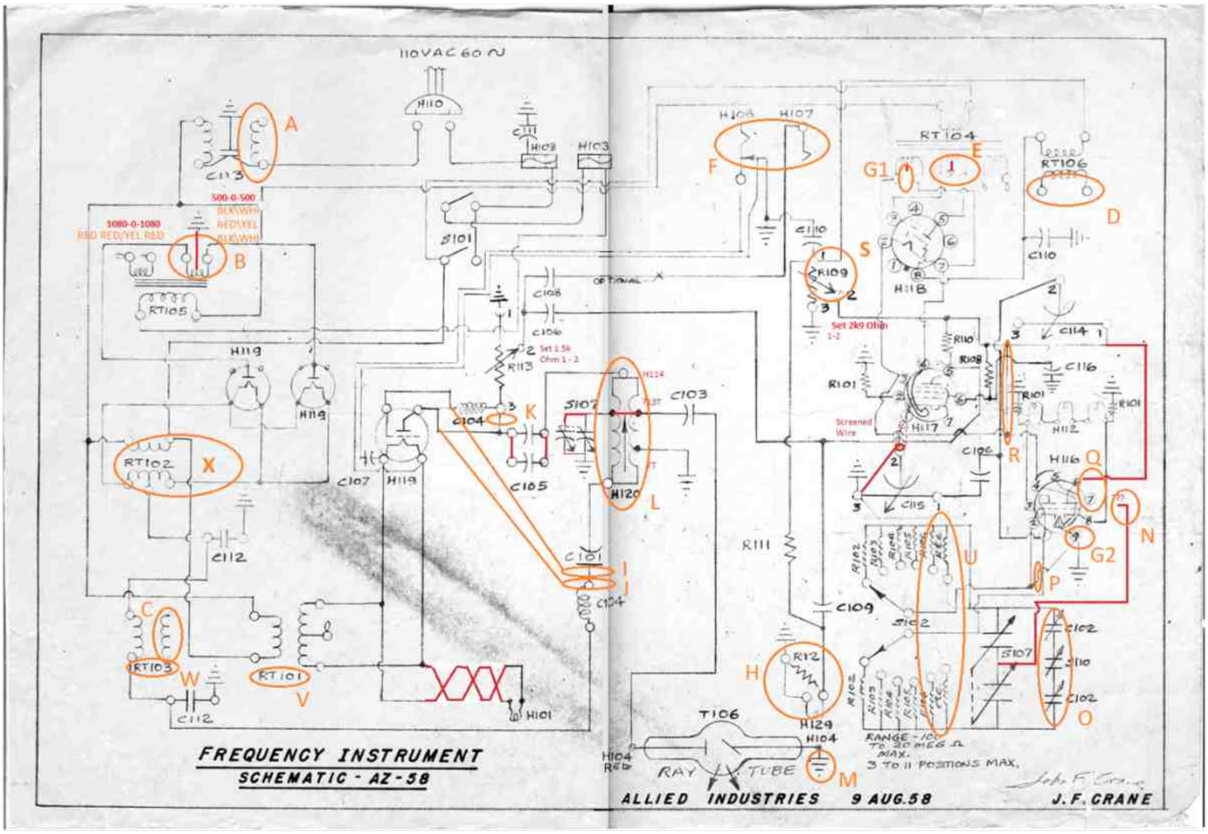


Figure 2 Allied Industries 1958 Schematic Diagram - Errors Noted

Labelling of components: It is usual to number components sequentially and uniquely, using a prefix in keeping with the components function C=Capacitor and R=Resistor. Crane managed to mix this basic concept up, e.g. C113 is a mains filter, granted it has a capacitor in it, but should not be labelled C113. C104 is a Potentiometer and should be labelled R104. Some variable capacitors carry the designation S107 which should be C107. S107 is used both to set the audio oscillator and to tune the carrier frequency, and in both cases is labelled S107 where normal convention would be a sequential sequence. The main inductor is labelled H120 this would be more conventionally L120 as an inductor. Generally Crane has used the H designator for chassis mounted hardware. In some cases components are not using the correct schematic symbols for instance, Choke RT106 should not have a secondary nor should the plate B+ choke RT101 in addition the core laminations are not shown, here we see the assumption that everything that looks like a transformer should have two windings. Neon lamp H129 uses a completely incorrect symbol. Ground symbols are should be orientated down, and not in any direction as drawn. It is clear that Johan Crane knew very little about art of drafting an electronic circuit, even though he had people around him like Vern Thompson, as well as much standard industry reference material. This is an indication to me that John Crane had only a rudimentary knowledge of electronic circuits, and was more of a practical draftsman; he could draw what he literally saw, and not see the function of the circuit. It is also observed that when he could see the internal structure of a valve such as the 812A or the rectifier's he was able to draw the correct internal structure.

List of circuit anomalies:

A. EMI Filter C113 one leg of inductor incorrectly connected.

B. HV Transformer RT105 has a RED-YEL centre tapped secondary, with the centre tap connected to earth as per the notes. The Merit P-3158 Plate transformer was a dual plate variety. The secondary's used would have been the 1080-0-1080 RED-RED/YEL-RED winding, and 500-0-500 BLK/WHI-RED/YEL-BLK/WHI winding.

( ) 26. Connect black and white stripe wires from RT105 to top of T101 tube connectors. (S). Connectors are H1?6 - ceramic grid caps.

Now connecting this way would be connecting the 500-0-500 volt winding. This must clearly be an error in the instructions, or Merit was capable of using different wiring colour codes from time to time.

( ) 33. Connect a wire from C112-3 to C112-2 to ground.(on chassis). Connect red and yellow stripe wire from RT105 to same ground. (S).

This is proof that a centre tap ground was used. It could never operate otherwise.

C. RT101 Merit C-3181 10H HV Smoothing choke only has one winding and no core and not labelled with the label mistakenly placed next to the filament t transformer RT103 (V).

D. RT106 Merit C-2995 8H Oscillator HV smoothing choke only has one winding, and no core.

E. RT104 Triad R-9A power transformer has a centre tapped secondary S1: 300-0-300 and a disused S2) 0-5V, as well as a S3: 6.3V CT Filament winding.

As it feeds a full wave rectifier the centre tap must be earthed, however the note 45 states the earth connection.

( ) 44. Connect two red wires from RT104 to H118 pin 3 & 5 (S).

( ) 45. Connect red and yellow stripe wire from RT104 to ground. Connect two green wires from RT104 to H118 pin 2 & 7 (NS). Tape off tan and green and yellow stripe wires from RT104. Connect one black wire to H118 pin 8 (S)..from RT106 - also black wire to R109-1 (S).

F. The telephone jack plug connectors are not correctly drawn, which could lead to a misunderstanding.

G. 1 and 2 The RT104 Triad R-9A filament transformer could be earthed on the centre tap. This is common practice, as the filament circuit can't be allowed to float. The earth could be applied to any of the ends of the winding, but as a centre tap lead is supplied it would have been the easiest to use that as the earth point; HOWEVER the one filament lead is actually earthed at pin 9 of H116 the 12AT7 dual triode. This earth will suffice. HOWEVER on the trimming table pin 9 is shown with a 6.3VAC reading which is only possible if this lead is not grounded, and the other end of the filament secondary is grounded. Changing this would require another filament power lead from H117 pin 4 to the H116 Pin 9. As this is not critical to the operation of this stage, it is sufficient that all tubes receive a 6.3V filament voltage, and there is a single ground at some point. I will elect to leave the H116 pin 9 and the central ground; it may result in slightly cleaner operation of the 12AT5 valve with less mains frequency feed through. Note 45 clears up the mystery and asks for the Grn/Yel wire to be taped off.

H. The H129 NE-T2 neon glow lamp is the incorrect symbol (incandescent lamp), and the current limit resistor R12 which should read R112 220k resistor needs to be in series with the lamp to limit its current. A resistor is almost never placed in parallel with a neon lamp.

I. The link between C101 and C104 needs to be Brocken. Point I on the Hartley oscillator is the feedback point just after C101 which needs to be directly connected to the grid of the triode 812A pin 3. This is standard practice. (Errors I , J and K come about due to confusion around which ceramic feed-through's H113 were connected to what, either side of the chassis. It is a simple swapping around mistake)

J. C104 is the plate choke feeding the HV B+ on to the anode of the 812A triode, and needs to be connected to the anode top cap of the tube. Again standard practice.

K. The link between C104 and C105 needs to be broken and is clearly an error.

L. Tank coil H120 is classically a +- 40 turn B&W 3906-1 2.5" air inductor. This is clearly the wrong symbol used here. The AZ-58 notes do NOT allude to an adjustment jumper from the C105 end of the coil as being the only adjustment permitted. (On reviewing the original wiring notes this is not that case and something James Cunningham added in as a way to adjust the plate loading etc.) The tap point for C103 is a bit of an anomaly.

( ) 58. Connect H127 to (S) H113 with screw on lug (S). Connect two of C105 .002 mfd capacitors from H113 to H114 (S) on lugs. Connect C101 on opposite end of H120 coil to H113 and H114 (S) on lugs. Connect a wire from coil no. 7 counting from end of C101 capacitor (S) to ground (S). (on bottom of coil.) Use woven wire on H127.

( ) 59. Connect C103 (S) to clip to no. 13 coil from rear Same as (No. 58) above to a wire (S) and connect to red H104 (S). Connect another wire 5/8" from wire of C103 as shown (S) and connect to S107 on rear of front panel and run to both lugs as shown (S) all.

Note 59 seems to say count 13 turns from the C101 end of the coil, but this would only be 13-7= 6T from the ground, a hopelessly small voltage to fire the ray tube. However if the Pictorial B is consulted, then it looks like 13 turns from the C105 end. I would say that is more correct, and bears out in practice.

M. It is clear that all the earlier devices and earlier AZ-58's in their pictures had a wire wound variable resistor (10k Rheostat) at this point, to be used for tube matching. Testing has shown how important this is. More on the subject later.

N. The centre point of the S107 audio oscillator tuning capacitor according to the wiring notes has an intended connection to H116 (Pin Unspecified Note 55) , which is required to form part of the Wien Bridge circuit. This classically would connect to one of the resistor banks wipers to form a series resonant circuit on the one side and a parallel resonant circuit on the other side. More on this issue later.

( ) 55. Connect a wire from H116 pin 6 (S) to C114-1 (S). Connect a wire from H116 (S) to the base screw on S107 (S). Connect R102 thru R106 as shown to S107 (S).

O. C102 and S110 trimming capacitors are not correctly configured. As shown here they all do the same function. We surmise that C102 are used to trim out the S107's individual tuning gangs, and S110 would be in parallel with the Cseries gang, to set the output amplitude of the oscillator. As this particular oscillator is working more in relaxation mode, it is quite ineffectual, and serves only to slightly adjust possibly the duty cycle. In a classic Wien bridge it would adjust the output amplitude by varying the impedance of the series leg, thus adjusting the 1/3 voltage divider formed between the two legs of the bridge. In trying to stabilise and calibrate the unit, it may have had all these adjustments added. The exact wiring of these trimmers is a mystery, the wiring instructions Note 61 are silent on the matter, referring to View D which is not present.

( ) 61. See view D for hook up of C102, S110, to S107. Connect wires and (S) as shown.

A mystery ground wire is also specified, but not shown.

( ) 57. Connect a wire from S107 (S) to ground (S) as shown. Rotate chassis for top side access. See Pictorial B.

Calibration notes 64 simply state "Adjust all trimmers", they are also slightly bulky components and do not feature on the chassis drawings at all.

CALIBRATION PROCEDURE

( ) 64. Allow the instrument to warm up for 15 minutes. Plug in the Frequency Counter on jack H107 or use outside probe. Calibrate instrument from 100 to 6000 cps maximum. Adjust all trimmers.

P. Depending which bank of resistors and capacitor gang is designated the series and which is the parallel portion, the parallel portion bank wiper would need to be earthed. In our chosen layout the earth point should be broken between H116 pin 2 and 9 and established between 1 and 9.

Q. H116 is a 12AT7 dual triode. First impression from the circuit diagram is that the 2^{nd} half of the triode's grid and anode are unconnected. However when the wiring notes are taken in to account as well as the tube voltage measurements, it is clear it was part of the circuit. Now for a normal linear oscillator to oscillate it needs to meet Barkhausen's criteria: Loop gain of one, loop phase of 360 degrees. This oscillator only has 180

Degrees of phase shift through one triode, and a cathode follower stage does not help as it is non-inverting as well. More on the audio stage later.

R. This link bridges the audio section B+ to the filament feed, which is clearly a huge error. It could have been the start of the HV link to H116 pin 6 which got incorrectly assigned.

S. It would have been a simple matter to connect C110 to R109 pin 2. This would have cleaned up the B+ fluctuations and the resulting edges of the square waves.

T. Intentionally Blank

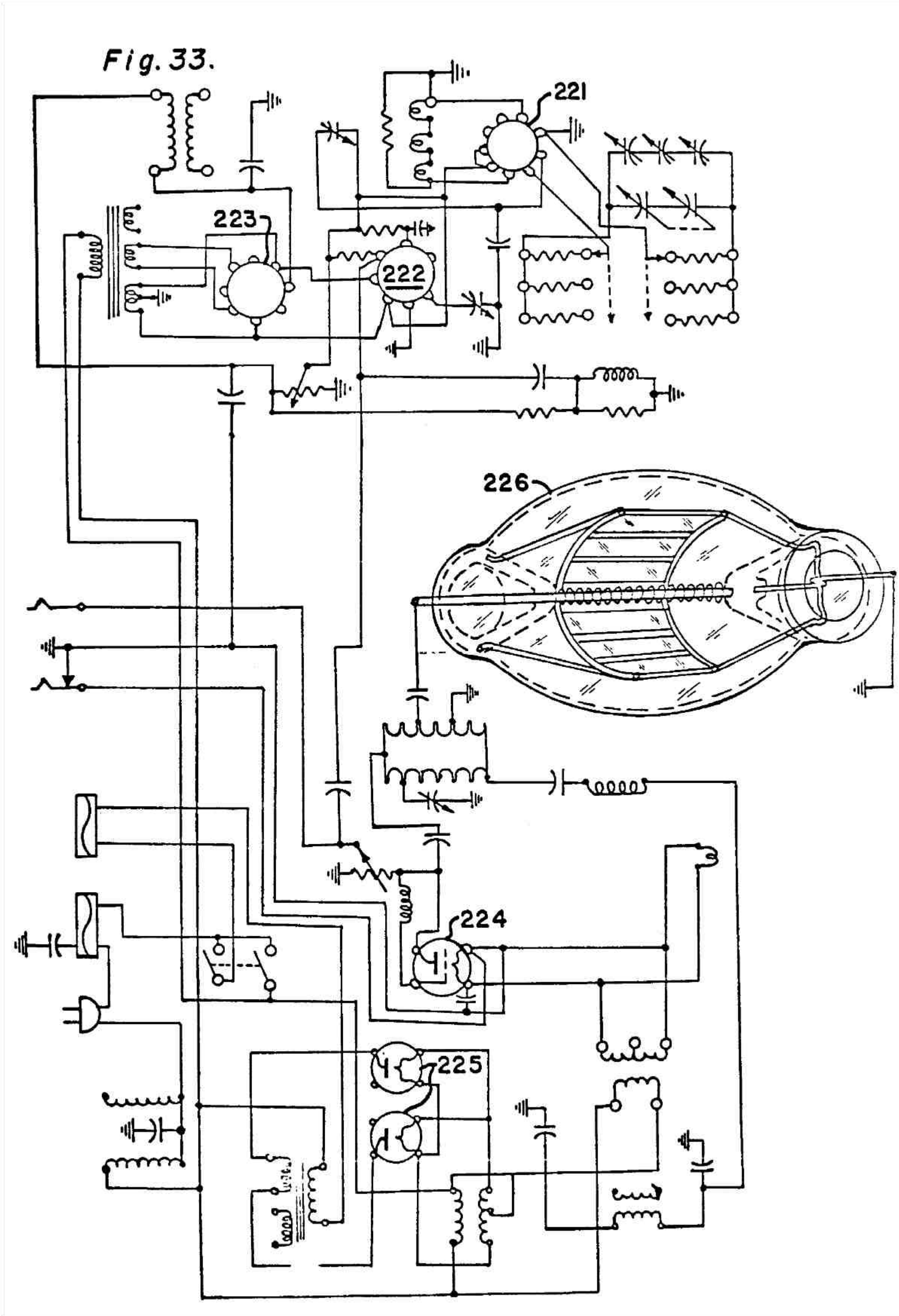
U. The resistor banks in application only had 3 – 5 range switch settings. This one has 6 and the note reference speaks of 11. This specification calls for 5.

V. The RT101 label belongs to the HV choke and not the indicated filament transformer

W. The filament transformer, and should be labelled RT103 a Merit P-*2947.*

X. RT102 Filament Transformer Triad F-3X incorrectly labelled P-3X in the parts listing is specified as a quantity of 2x. The part voltage is 2.5V CT, as the 816 rectifier requires 2.5 V the part would have to be 1 x 5V CT or 2 x 2.5V CT the drawing does not reflect the 2 x P-3X. This part has a feature that supports some of the earlier history of this design, more later on.

The following additional diagram carries even more errors; it just gets worse with time!



Y.

Figure 3 Crane 1973 Patent Application Page 88

The above diagram has clearly been redrafted and carries a lot of the original errors, as well as a lot more. For example variable resistors have become variable capacitors. Funny enough the error G reported previously the centre tap of the audio stage filament transformer has been partially fixed! The range switch now only supporting 3 positions. True to usual patent form, this circuit is unbuildable!

Here are some extracts from the 1973 Crane patent application:

Fig. 33 is an electronic diagram of the Ray Tube Frequency Instrument which consists of a Hartley Oscillator modulated with a

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square wave generator. The RF energy level is in excess of 8000 volts and the ray tube is generally filled to 15 mm of helium gas after thorough evacuation providing a brilliant pink discharge glow when activated as an antenna to transmit audio frequencies. The unit has been supplemented with a Frequency Counter to monitor the critical resonant frequencies induced from the variable oscillator.

The specifications are for my experimental model No. AZ-58: (1) Audio range 50 to 6000 Hz,(2) Modulated carrier range 4680 KHz, (3) Distortion - less than 0.6 per cent, (4) Input power requirements - 350 watts, 105 - 125 volts, 50 - 60 cycles per second A.C., (5) Output voltage - 7000 to 15,000 volts to the Ray Tube, (6) Audio Frequency Calibration by frequency counter will be made for each individual microorganism at time of installation as follows: Tetanus, Treptonema, Gonorrhea, Typhoid, Staphlococci, Pneumonia, Tuberculosis, Streptothrix, Bacillus Coli, Sarcoma, Carcinoma, Strepococci, etc.: special settings for other diseases on request, including the common cold and flu viruses, (7) Treatment time is normally three minutes for each calibrated dial setting. A three day interval is suggested between treatments to allow the lympatic system to recover from its overload caused by the cosmic devitalizations. Unlike the preferred embodiment of the application of 5 volts in the human body by direct contact of the Frequency Instrument, and by 50 volts of the Virus Eliminator, the Ray Tube Frequency Instrument has its preferred embodiment from the ray tube which occurs when the circuit is tuned and trimmed to the following values:

TUBE	NUMBER	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9
12AT7 (H116)	221 (T102)	200 VDC	NR	4.25 VDC	NR	NR	290 VDC	NR	6 VDC	6.5 VAC
6AQ5 (H117)	222 (T103)	4 VAC	4.25 VDC	6.2 VAC	140 VDC	105 VAC	4 VAC			
6X5GT (H118)	223 (T104)	NR	300 VAC	NR	300 VAC	NR	NR	800 VAC		
812-A (H119)	224 (T105)	6 VAC	NR	195 VAC	6 VAC	[Plate = 2900 VDC]				
816 (H119)	225 (T101)	2500 VDC	3500VAC (Plate)		2500 VDC	[Heater = 6.6 VDC]				

Note: NR: Means Not Readable or No Connection to Pin.

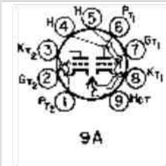
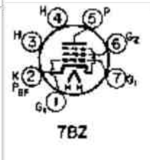
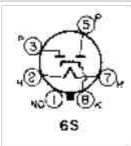
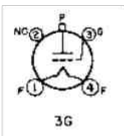
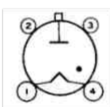
The voltage delivered to the Ray Tube Antenna is preferred at 9K Volts; carrier frequency at 40 to 90 MegaHz and distance to target of the human body is twelve inches for five minutes duration in the treatment of cancer and other diseases. Ray tube 226 is on Fig. 33. The ray tube 226 has mirrors to concentrate energies.

Figure 4 Crane 1973 Patent Application AZ-58 Notes Pages 49 – 51

In order to diagnose and calibrate a piece of equipment it is usual to list a table of measured voltages from a working unit. That way a technician can easily diagnose a faulty condition or calibrate the instrument. These readings are important as they give us some clues as to how the instrument would have been set up.

1. The above setting table is interesting: H116 Pin 6 is carrying a 290VDC reading; this is only possible if it is connected to a high voltage source either direct or via a resistor! This clearly indicates missing circuitry around the 12AT6.
2. H116 Pin 9 the heater centre tap is showing 6.5VAC this is a filament voltage. That means that this pin is 6.4V relative to the chassis. This can only be the case if it is not tied to ground at this point, and the filament transformer is not centre tapped, but grounded on the other lead, hence the NR on the other two heater pins 4 and 5. This is a 12V filament, but when the two halves are paralleled it will operate on 6.3 VAC.
3. H117 6AQ5 Pentode has several erroneous readings.
4. H118 6X5GT Rectifier – Voltages are on entirely the wrong pins.
5. H119 812A lists a Plate voltage of 2900V DC as well as H119 816 Rectifier tubes list an AC voltage of 3500VAC as well as a B+ voltage of 2500V DC. This is all way above what the 812A tube can handle, and gives us the idea that some of these readings come from earlier notes using another type of power triode and much higher B+ voltages. Could the Beam Rays

original machines developed by Hoyland have run at these high voltages? Some more evidence in later discussions.

TUBE	NUMBER	PIN	PIN	PIN	PIN	PIN	PIN	PIN	PIN	PIN	
BASE		1	2	3	4	5	6	7	8	9	
Double Triode		1	2	3	4	5	6	7	8	9	
		PT2	GT2	KT2	H	H	PT1	GT1	KT1	Hct	
12AT7	221	200	NR	6.6 (4.25)	GND	GND	140 (290)	131 (NR)	7.5 (6)	6.3	
(H116)	(T102)	VDC		VDC	0 VAC	0 VAC	VDC	VDC	VDC	VAC	
		Adjust C114 164 Vp-p, 108 Vrms					236 Vp-p, 100 Vrms				
		9 Pin Shielded Base Socket									
Beam Pentode		1	2	3	4	5	6	7			
		G1	K	H	H	P	G2	G1			
12AQ5 (6A	222	4	3.5 (4.25)	GND	11.7 (6.2)	98 (140)	120 (105)	4			
(H117)	(T103)	VAC	VDC	0 VAC	VAC	VAC (VDC)	VDC (VAC)	VAC			
		Adjust C115									
		7 Pin									
Full Wave Rectifier		1	2	3	4	5	6	7	8		
		NC	H	P	NP	P	NP	H	K		
6X5GT	223	NR	6.3	300	NR	300	NR	GND	366 (800)		
(H118)	(T104)		VAC	VAC		VAC		0 VAC	VDC		
			NR								
		8 Pin Octal S Type									
Power Triode		1	2	3	4	TOPCAP					
		F	NC	G	F	P					
812-A	224	6.3	NR	180 (195)	GND	[Plate = 1000 VDC]					
(H119)	(T105)	VAC		Vp-p (VAC)	0 VAC						
		4 Pin S Type									
Half-Wave Mercury-Vapour Rectifier		1	2	3	4	TOPCAP					
		F	NC	NC	F,K	A					
816	225	1000			1000	1080 VAC	[Heater = 2.5 VAC]				
(H119)	(T101)	VDC			VDC	(Plate)					
		4 Pin S Type									

The above table has been corrected and true readings from my AZ-58 replica inserted – Calibration is carried out at 1khz. Voltages are measured using a HP 54601A Oscilloscope. High voltages are measured directly with a 1000:1 15kV probe. VAC = RMS readings.

It was observed that electromagnetic energy utilizing a frequency of 2127 cycles per second modulated on a carrier wave of 4150 kilocycles at 200 watts was lethal to cancer. Such virus as cancer and other viruses such as tuberculosis, typhoid, polio and many others are a threat to health in water. A great many other viruses have been destroyed by subjecting them to transmitted electromagnetic energy of frequencies which are resonant or harmonic with such virus. The precise frequency required for their demise and control is set forth in the following table:

Tetanus 120 cps, treponema 660 cps, gonorrhea 712, typhoid 712 cps, staphlococci 728 c ps, pneumonia 776 cps, streptothrix 784 cps, bacillus coli rod 800 cps, tuberculosis rod 803 cps, streptococci 880 cps, tuberculosis virus 1552 cps, sarcoma virus 2008, carcinoma virus 2127 cps.

Figure 5 Crane 1973 Patent Application Page 40

Suddenly there is mention of the 4150 KC carrier again!

Circuit Anomalies

The following Anomalies are noted:

1. Crane receives a schematic diagram from Dr Grunner in the correct form of a schematic, but his own two schematic drawings of the AZ-58 are more of a wiring diagram, almost reverse engineered of a physical device. Why would Vern Thompson not have documented the AZ-58 in the proper schematic form, and why would Crane an astute draftsman not have latched on to the proper form of a schematic diagram? Why are there so many obvious errors on the circuit diagram?
2. Why did Dr Rife and Vern Thompson make a patent application in 1956, in the middle of their association with John Crane and John March ? Were there two groups at this time, the Rife/Thompson and the Crane/Marsh with certain information withheld from each other like a proper functioning schematic diagram?
3. Why did the AZ-58 Audio Oscillator not follow the Hewlett-Packard, or even the form used in the pad devices like the EICO 377 form? Instead we have a Wien Bridge oscillator configuration. If Verne Thompson used the EICO 377 design in the Aubrey Scoon 39' Replica, then why was this not carried through to the AZ-58 being a far more superior oscillator – Were they afraid of some patent infringement as they planned to commercialise the units ?

More likely the EICO solution came after the 6 AZ-58 units were built and represented a more accurate off the shelf solution.

4. If the AZ-58 was named as the product released in 1958, what was it called during its development life cycle from 1950 – 1958 ?
5. If the Grunner machine as depicted in the schematics was a current Hoyland design, using transformer intersage coupling, why was that moved away to a direct coupling method. Then why are we not seeing interstage transformers in other supposed Hoyland devices ?
6. Why if the proper form of filament balancing on the RF Triode was well known, did all designs persist with an unbalanced filament, which would bleed through mains frequency modulation in to the grid ?
7. Why is Crane so fixated on high voltage output, which was impossible from the AZ-58 design, both in terms of the transformers used as well as the 812 tube maximum outputs? In the Crane patent it clearly shows a B+ voltage of 2900V. This must be a throwback to some earlier specification that Hoyland possibly used? How were output voltages of over 8000V measured and reported ?
8. Why were there so many stated carrier frequencies?
9. Why was a tube matching resistor dropped in the final diagram?
10. Why does the diagram have 6 frequency ranges when only xx were used in reality? In addition the diagram mentions 3 – 11 positions!
11. Grid bias resistor, this has a to low a resistance for the previous stage to even modulate it properly?
12. Modulation control?
13. Why are the Crane frequencies 1/10 of the Beam Rays MOR frequencies?

To my mind John Crane was a practical mechanical man, when he looked at electronic equipment all he could see were wires. He understood larger level functional blocks and some of the obvious components. Vern Thompson being a radio man would have known the proper form of schematic documentation and taking proper readings. Clearly he must have had his own private notes, and never revealed this to John Crane. Was this because he had designs on a closer partnership with Dr Rife given their 1955 patent application? or did he somehow feel these were his and Dr Rife's ideas which pre-dated the association with John Crane. John Marsh on the other hand was able to subsequently build two improved versions of the frequency instrument. To do so would have required expert level knowledge of the subject, why did he not assist John Crane to get the schematics right? Judging from the letters John Marsh was equally clueless (The burned resistor, and detached tuning capacitor event), I am not sure how he managed to build such elaborate devices after his association with Crane. Given that they were closing in on a manufacturing relationship for Dr Stafford it is possible that a documentation pack was drawn up for manufacturing discussion, but modified so as not to make any practical sense. (PACK FOR UNI PROF TO LOOK AT) I think this could have been true to a point; however some of the other errors are too embarrassing for anyone in the know. Some have advocated that these drawings were draft, then why would john Crane sign them and use them in his 1973 patent application; I suggest that to his mind there was nothing wrong with them! It is a great pity that the electronic men associated with Dr Rife (Lee De Forrest, Philip Hoyland, Verne Thompson, John Chamblin..) kept all the actual circuits to themselves, leaving the likes of John Crane to fend for himself to build up a schematic by manually tracing out the wiring from an existing instrument.

Fortunately for us there is enough evidence scattered around to fill in some of the missing blanks, at least for certain time periods.

AZ-58 Development History

The AZ-58 was developed over a period from 1953 to 1958. There is some discussion and photographic evidence that supports the evolution process, whereby the machine became more effective over time, as is noted by feedback obtained from Dr Stafford and Dr Jeppson. First there was Verne Thompson with his prior Beam Ray's and other instrument building/repair experience, then there was the Beam Ray's instrument refurbished to treat John Marsh's wife, then there was the Dr Grunner schematic, all of this was input in to building the AZ-58. In order to finalise a design specification there must have been some experimentation work done to decide on the square vs sine wave modulation, ultimate choice of audio oscillator design and carrier wave.

Let's examine what shaped the development process.

Instrument	Beam Ray's	Aubrey Scoon	Thompson	Allied Industries	Allied Industries	Allied Industries	Allied Industries	Allied Industries	Allied Industries	John Marsh
Revision				AZ-58 - 1	AZ-58 - 2	AZ-58 - 3	AZ-58 - 4	AZ-58 - 5	AZ-58 - 6	# JLMSQ-1A
Picture										
Period of Manufacture	1938/39	1952 - 1956	1954-	Sep-53	1953	1953	1957	1957	1958	1970
Designer	Hoyland	Thompson	Thompson	Crane/Thompson	Crane/Thompson	Crane/Thompson	Crane/Thompson	Crane/Thompson	Crane	Marsh
Hartley Oscillator	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Variable	Variable	Variable	Variable
Carrier Frequency	3.8 Mc	3.3 Mc	xx	4.15 Mc	4.15 Mc	4.15 Mc	3.1 - 3.3Mc	4.68 Mc	4.68 Mc	4.122 MHz
Plate Current Meter	300mA	No	No	Yes	Yes	No	No	No	No	Power/SWR Meter
Audio Wave	Sine	Sine	Sine	Square	Square	Square	Square	Square	Square	Sine / Square
Audio Design	HP Style	Eico 377	Eico 377	?	?	?	?	?	?	
Audio Range	160Hz – 42.6kHz	20Hz – 200kHz	20Hz – 200kHz	50Hz – 6kHz	50Hz – 6kHz	50Hz – 6kHz	50Hz – 6kHz	50Hz – 6kHz	16Hz – 6kHz	20Hz – 200kHz
Audio Band Switch	4 Band	4 Band	4 Band	3 Band	3 Band	3 Band	3 Band	3 Band	5 Band	3 Band
Audio Dial	Vernier Style	0-100 in 180deg	0-100 in 180deg	ACN Vernier,180Deg	ACN Vernier,180Deg	ACN Vernier,180Deg	ACN Vernier,180Deg	ACN Vernier,180Deg	ACN Vernier,180Deg	Digital
Modulation/Amplitude	Variable	Variable	Variable	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	
Timer	15 min	No	No	No	No	No	No	No	No	5 Min
Tube Matching/Intensity	??	Fixed	4 Step	?	?	Fixed	Fixed	?	Jumper	Variable + SWR Adj,
Ray Tube	 									
Construction	Split RF/Audio,PSU	Split RF/PSU, Audio	Intergrated	Intergrated	Intergrated	Intergrated	Intergrated	Intergrated	New Aluminium cabinet	Split RF/Audio, PSU
Notes	Stacked Case	Stacked Case	Compact Case	Narrow Chassis	Wide Chassis	Wide Chassis	Wide Chassis	Wide Chassis	Narrow Chassis	Dual Cabinet
			Photos by Jim Bare		AZ-58 #5		Dr Stafford	Additional dial / swich top RHS	We only have the circuit diagram.	
			Had Dial based frequency list		Rockwell	Rife/Thompson filed a patent application in 1956 citing the carrier as 4.15 MC		http://www.rife.org/letters/581022crane.jpg	July 1959 Paint tube 1/2 5 Coats aluminium Paint	
		Frequencies are 10 x Crane	Frequencies are close to Crane		Rife/Thompson Patent 4.15 Mc 1956		Carrier range measured as (2.4 - 4.68)	Top Right Carreir Frequency	AZ-58 #2 Radiation Tested	
							HP 521-A Direct Frequency Counter		Spec 4.5 - 10.5 Mc	
							Heathkit PM-1 RF Power Meter		Schematic/Test Report 1958 4.68 Mc	

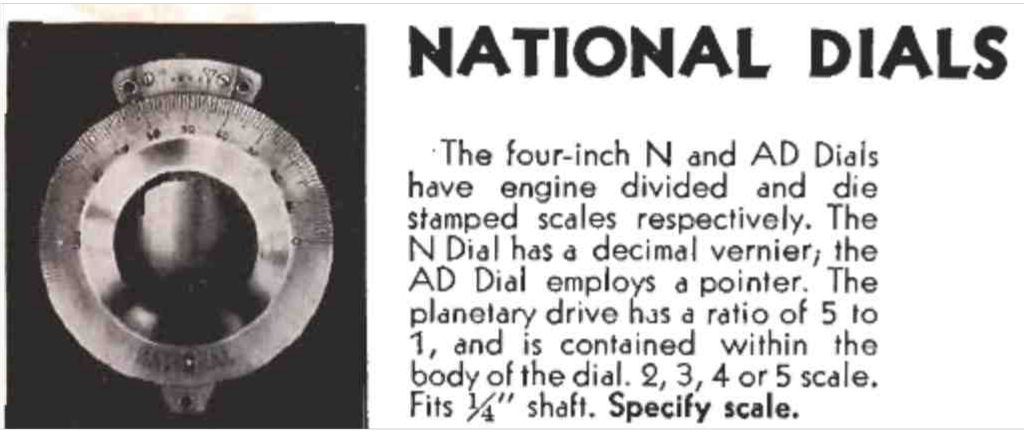
Vern Thompson's prior instrument building/repair experience:

Beam Rays Instrument 1938/39

Figure 6 Beam Ray Instrument 1938/39

This is typical of the instument that Verne Thompson would have repaired in the 1940's for Dr Rife. He would have known intematly how this instrument was put together and calibrated. Especialy as Dr Yales instument was tested bt Dr Rife to devitelise pathogens in the lab. This is most likely the sort of instument that was repaired to treat John Marsh's wife.

Did this one use a National N dial ?



(Fixed Hartley Osc , Plate Current Meter 300mA , Sine Wave Audio Generator 160Hz – 42.6kHz, Range Switch 4 Band, Audio Freq. Dial Vernier, Modulation Amplitude, 15 Min Timer, ? Tube Matching ?)

The British Rife Groups 1952 – 1956 Beam Rays replica

Figure 7 Aubrey Scoon 39 Instrument most likely dated to 1952 onwards

This instrument used the Eico 377 kit audio oscillator, and had a tube matching resistor as was depicted in the Aubrey Scoon circuit diagram. Dr Rife made some comments about Verne Thompson stepping up the power levels on certain instruments. By matching the ray tubes to the instrument would have ensured this. REFERENCE

Dating this instrument relies on the availability of the Eico 377K Kit from 52/53 onwards as well as the diary page found with the device showing a Wednesday 1st February. This corresponds to 1939 and 1956. 1956 Is a more likely date due to Eico 377 non availability? It is possible the instrument was upgrades in the Audio section, but I don't think so as the audio generator chassis is pristine with no extra holes in it. It certainly pre-dates the compact single chassis frequency instruments.

The Scoon frequencies were extrapolated off the Eico 377 dial face, using a technique discussed later.

Pathogen	Band	Dial	Measured Frequency (Hz)	Eico 377K Frequency	Err %
BX	4	10	21 275	23 430	10.1%
Sarcoma	4	6.5	20 080	22 193	10.5%
Typhoid Virus	3	94	18 620	17 925	-3.7%
Tetanus	2	78.5	1 200	1 220	1.6%
Treponema	3	56	6 600	6 679	1.2%
GC+Typhoid?	3	58.5	6 900	7 159	3.8%
Staphylococcus	3	59	7 270	7 259	-0.1%
Pneumonia	3	61	7 660	7 674	0.2%
Streptothrix	3	61.5	7 870	7 781	-1.1%
Coli Rod	3	62	8 020	7 889	-1.6%
TB Rod	3	63	8 300	8 109	-2.3%
Streptococcus	3	63.5	8 450	8 221	-2.7%
TB Coli Virus	3	88	16 000	15 508	-3.1%
Coli Virus	3	89.5	17 220	16 100	-6.5%
Worms	3	24	2 400	3 054	27.2%

Ignoring Worms there is a 0.4% average error in results. Possibly due to slightly different alignment of the dial or calibration. I think it is close enough to question the Worms reading and possibly the BX and Sarcoma!

(Fixed Hartley Osc , Sine / ? Square Wave Audio Generator 20Hz – 200kHz, Range Switch 4 Band, Audio Freq. Dial, Modulation Amplitude, Fixed Ray Tube Matching)

Vern Thompson – 1954 Instrument

(Fixed Hartley Osc , Sine Wave Audio Generator, Range Switch 4 Band, Audio Freq. Dial, Modulation Amplitude, Variable 4 position Ray Tube Matching)

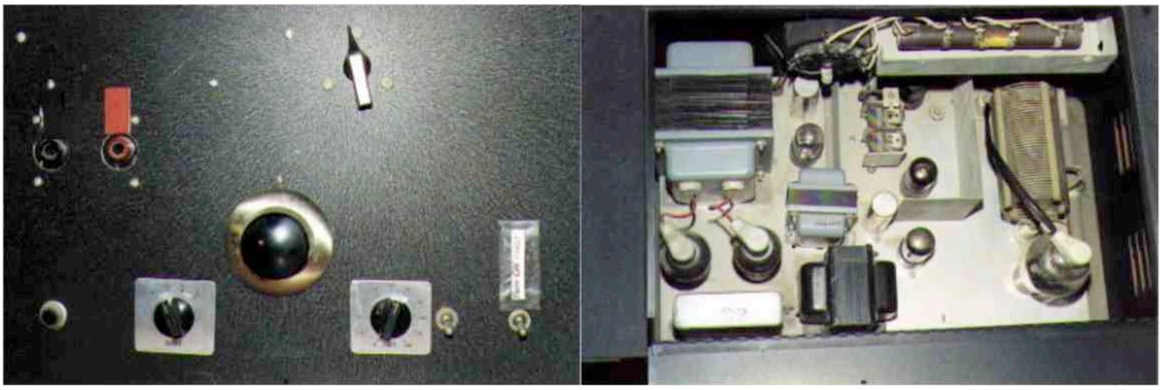


Figure 8 Another Vern Thompson Instrument documented by James Bare

This instrument built by Vern Thompson, follows an evolutionary path of making the device more compact with all the components on a single chassis. Which logically would have come after the Scoon device. Only 3 tubes are visible in the audio oscillator section, so this may have been an Eico 377 without the square wave shaping circuit. I am sure Vern Thompson would have stuck with a tried and tested design, however he has deviated from the Eico component placement so rigorously followed in the earlier device. Notice the 4 position switch to select in varying ray tube matching impedances. This could have been a logical progression from the prior pre-set wire wound arrangement. http://www.rife.org/vthompsonphotos.html In dating this device a discerning feature would be the Eico Genrator after 1952/53 as well as the Triad plate transformer. This particular one with the thin HT wires first appeared in the 1954 Triad catalogue. All prior ones had thick black wires. We can safely date this device to 1954 onwards. Similar in timeline to the AZ-58 and the Scoon Devcie.

Figure 9 Triad 1954 Plate Transformer

The following close up pictures of the audio section confirm it is an Eico 377 audio generator:

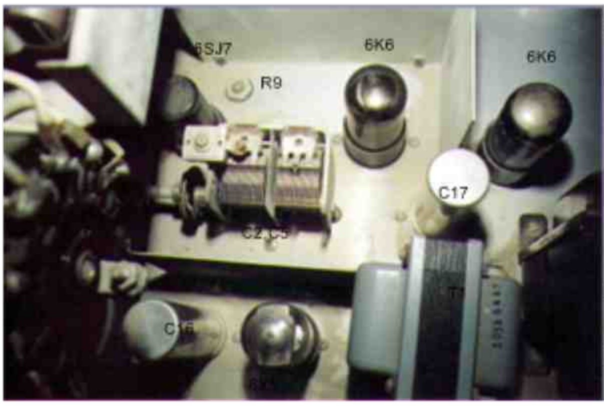


Figure 10 VT Audio Stage

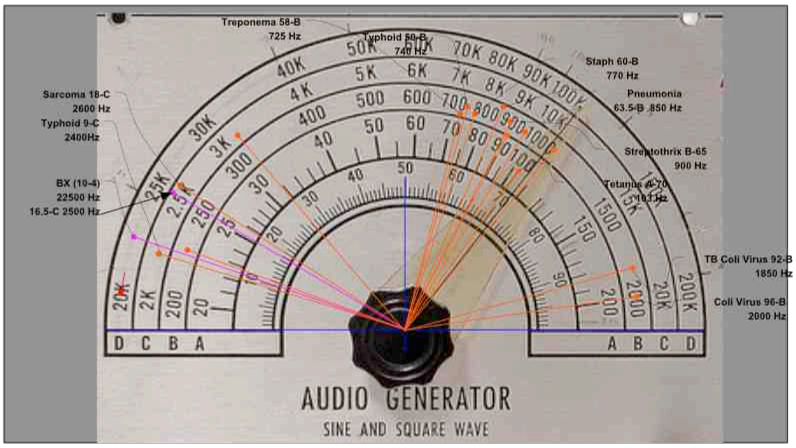
Figure 11 EICO 377 Generator

Notice the tuning cap is identical, same trimmer, tubes 6SJ7,6K6,R9,C16,C17,6K6 all match up. The only exception is the square wave shaping section 6SN7 that is missing. This is interesting as it was present on the Scoon devcie. I would assume by this stage Verne Thompson knows what he wants, and is comfortable to choose his own component locations so he drops the 6SN7 square wave shaper and makes the layout more compact.

Now a frequency list acompanied this devcie:

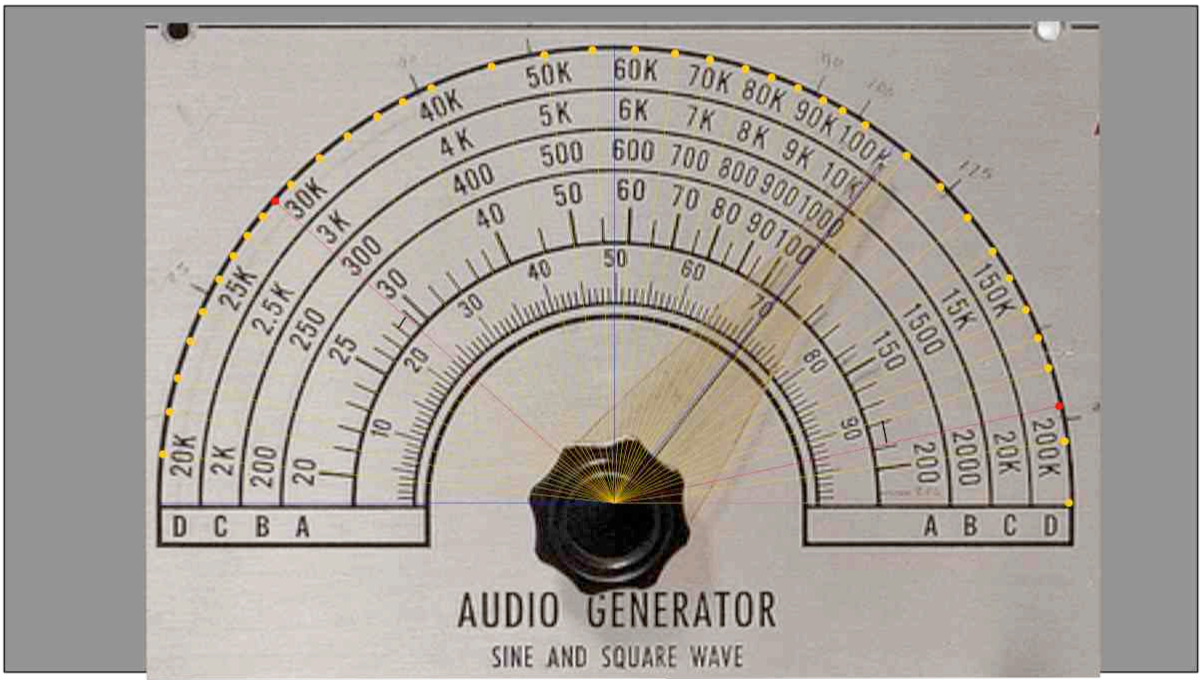
TETANUS.........................70-A
HAY FEVER.......................54B
TREPONEMA.......................58-B X
G.C/ typhoid....................59-B
ASIAN FLU.......................60-B X
STAPHS..........................60½-B X
DEBRIS..............A-50..49½...A-62 X
PNEUMONIA.......................63½-B X
STREPTOTHRIX....................65-B
COLI ROD........................65½-B
T.B.ROD.........................65 3/4 B
STREPTOCOCCUS...................67½-B X
T.B. COLI VIRUS.................92-B
COLI VIRUS......................96-B
1918 Flu....C-27...B72..... .....11-B X
TYPHOID VIRUS...................9-C
SARCOMA.........................15-C
B.X.............................16½-C
Box VIR 10-4

Now seen as we know what an EICO 377K face panel looks like we can use it to decode the dial, range settings in to actual frequencies. The frequencies were roughly laid out on the dial face, and the frequencies extrapolated.



Then I decided that we needed a far more accurate method of looking up a dial setting and getting a corresponding reading with a high degree of accuracy. So every fixed frequency position in the A range was marked up and the corresponding dial setting 0 – 100 was read off under a high degree of magnification.

Calibration



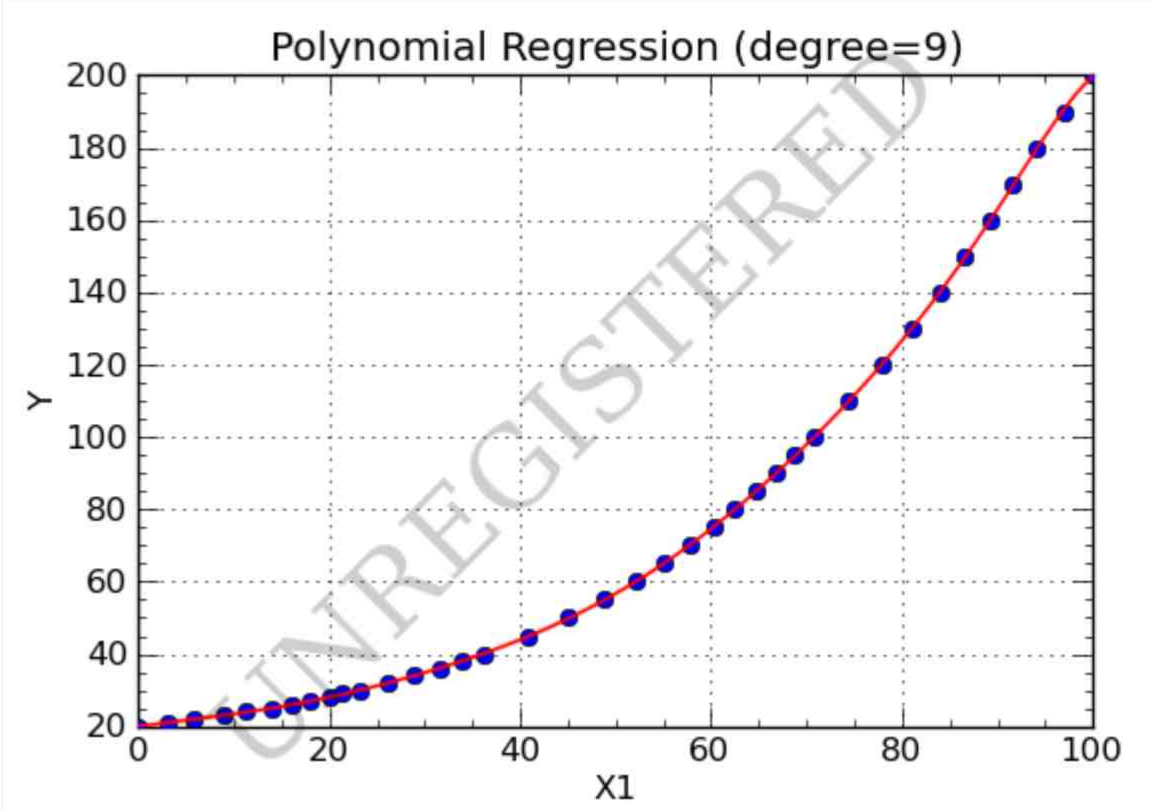
Now you will observe that the Eicon 377 starts their 20 Hz range at dial position #3.5 and ends at 200 Hz #95.5.

In reality the Eicon 377 reads the following stop (#0) to stop (#100): (Thanks to Jim Armstrong for the readings off his calibrated instrument)

- Band A stop to stop 18.5 - 195
- Band B 186 - 203
- Band C 1 879 - 21 025
- Band D 18 980 - 207 770

The Scoon ranges were read stop to stop as #0 being 20 hz and #100 being 200Hz. So I extrapolated the Eicon scale so that 20Hz lines up with #0 and 200Hz line up with 200Hz, then used that data set for the regression.

Then the data was processed to find a good curve fit using a 9th order polynomial regression with a 0.27% fit error. The red lines on the dial indicate two points where the dial spacing deviated from the norm and was visualy corrected. This could have been an origional artwork error, given that it was a manual process back in the day.



Now we have an equasion from which to extrapolate any frequency. This will also apply to the Scoon devcie.

Microorganism	Band	Dial	EICO 377K Freq. Hz	Note	Scoon Device	% Err
Tetanus	A	70	98		1 200	-18.4%
Hay Fever	B	54	632			
Tresponema	B	58	706	x	6 600	7.0%
G.C / Typhoid	B	59	726		18 620	-61.0%
Asian Flue	B	60	746	x		
Staphs	B	60.5	757	x	7 270	4.1%
Debris	A	50	57	x		
Debris	A	62	79	x		
Pneumonia	B	63.5	822	x	7 660	7.3%
Streptothrix	B	65	857		7 870	8.8%
Coli Rod	B	65.5	868		8 020	8.3%
TB Rod	B	65.75	874		8 300	5.3%

Streptococcus	B	67.5	916	x	8 450	8.5%
TB Coli Virus	B	92	1 711		16 000	7.0%
Coli virus	B	96	1 871		17 220	8.6%
1018 Flue	B	11	238			
1018 Flue	B	72	1 032			
1018 Flue	C	27	3 261			
Typhoid Virus	C	9	2 306		18 620	23.9%
Sarcoma	C	13	2 462		20 080	22.6%
BX	C	16.5	2 621		21 275	23.2%
BX	4	10	23 430	Hand Note	21 275	10.1%

Now here is something interesting, this devices frequencies are aproximatly 1/10 of the Scoon devcie frequencies! I have compared the % Error on that basis. The average error ignoring the two large anmomalies and the last row is 11.2%. Some of this error may be due to an offset/calibration error in terms of how this device was calibrated. Using sine waves on square wave frequency ranges is possible as when a sine wave is overmodulating the carrier it has the appearance of a square wave envelope. This instrument may have been the very first instrument to use a version of the so called Crane square wave frequencies.

The Excel equasion is as follows:

F(x)=(a+b*x+c*x^2+d*x^3+e*x^4+f*x^5+g*x^6+h*x^7+i*x^8+j*x^9+k*x^10)*IF(J10="A",1,IF(J10="B",10,IF(J10="C",100,IF(J10="D",1000,0))))

a to k are the polynomial coeficients. I just place them in named range fields a,b..k etc.

a = 1.997881930977329E+01
b = 3.492322017638088E-01
c = -8.983135611568741E-04
d = -4.424144418458491E-04
e = 7.913933232450654E-05
f = -3.798235625610368E-06
g = 9.063921829342229E-08
h = -1.156078296010743E-09
i = 7.548203263874133E-12
j = -1.984873695650033E-14
k = 0
Where x is the dial reading 0 to 100, and J10 contains the frequency band range A,B,C or D

The AZ-58 Range

The AZ-58 is a range of 6 instruments manufactured in 1953 and optimised till after 1958. Most likely the original work was done by Verne Thompson, but later modifications could have been effected by John Crane with the help of John March. Dr Rife was also in full attendance at the time.

AZ-58 Specification

- Audio frequency range 100 (50) to 6000 CPS – 1953 to 1957 in 3 Ranges
  - Range 1: 66 to 236 CPS (18 June 1958 Lab Test Report)

  - Range 2: to 1176 CPS
  - Range 3: to 5664 CPS
- Audio frequency range 20 to 6000 CPS – 1958 in 5 Ranges
  - Range 1: 20 to 40 CPS (Measured on Replica)
  - Range 2: 22 to 65 CPS (Measured on Replica)
  - Range 3: 66 to 236 CPS (18 June 1958 Lab Test Report)
  - Range 4: to 1176 CPS
  - Range 5: to 5664 CPS
- Radio frequency range 4680 KC per FCC.
  (4.68 M.C as per schematic and Lab testing, 3.1 – 3.3 M.C. as per Dr Stafford, 4.15 MC as per Rife/Thompson patent 1956) 4.5 M.C to 10.5 M.C – The role of the carrier was not well recognised, and server to either adjust the intensity of the tube, or comply with FCC guidelines of the Marine Band (FCC 4680 +-20 KC). Other carriers were discussed up to 40 and 90 MHz which is clearly out of this machines capability.
- Distortion Less than 0.6% +- 50 cps calibrated
- Maximum power input 350 watts full power to 200watts, 105 – 125 volt 60 cycles AC
- Maximum power output 20 RF watts from the applicator
- Overall Dimensions 14 7/8" high, 21 9/16" wide, 13" deep
- Output voltage 8250 RMS maximum at 50 to 300ma (Lab Test Report 56-58mA@8050-8250V (rms) or 463 to 467 Watts) 1973 Patent App list 7kV to 15kV with 9kV preferred!
- Shipping wt. 40 lbs.
- Ray Tube
  - 90 Degree and 45 Degree Electrodes
  - 1" Separation
  - Angled Electrode – Cathode (Negative, ground)
  - 14 - 15mm Helium Gas

The AZ-58 Treatment Frequencies

This information principally comes from Dr Stafford's report and various letters, but was only revealed to him in 1959 when Crane asked him to check the calibration of both the AZ-58 and the Heathkit AO-1 Pad Device he was using.

Microorganism	Band	Dial	Frequency C.P.S	Dr Stafford Protocol 3.1 - 3.3 MC Carrier
Tetanus	1		120	
Treponema	2		660	
Gonorrhoea	2		712	
Staphylococci	2	85	728	X
Pneumococci	2		778	
Streptothrix (fungus)	2	91	784	X
Streptococci	2	99	880	X
Typhoid bacteria	2		712	
Typhoid virus	3		1862	
Bacillus Coli Rod Form	2		800	
Bacillus Coli Virus	3		1552	

Tuberculosis Rod Form	2		803	
Tuberculosis Virus	3		1552	
Sarcoma (all forms)	3	27	2008	X
Carcinoma (all forms)	3	30	2128	X

The actual source of these low frequency MOR's is somewhat of a mystery, when compared to the Rife #4 machines clear use of frequency. Jeff Garf has put forward a rather convincing argument around the interplay between carrier harmonics and modulation frequency, as well as the frequency multiplication factor emanating from a plasma ray tube. The only problem with this theory is that the carrier has to be tightly controlled which it was not, and possibly Philip Hoyland was individually tuning machines in the lab and publishing dial settings that effected the MOR's. The history record shows us that John Crane received the frequencies from Dr Rife and Verne Thompson in the 50's REF and Vern Thompson's other devices used similar and 10x type frequencies.

Carrier Frequencies:

Rife / Thompson filed a patent application in 1956 listing the carrier frequency as 4.15 MC. As both these men were professionals, I believe the earlier 1953 to 1956/57 carrier was 4.15 MC. It was possible by vary the carrier in step's by shorting out turns on the Hartley Oscillator tank coil on the feed end, however the wiring instructions do not offer that option, that was input from James Cunningham the broadcast engineer who built the first AZ-58 replica. In 1957 Dr Stafford started asking questions about the correct carrier, and a variable capacitor was fitted in October 1957 LINK by March/Crane most likely Crane as March had to re-solder the capacitor lead that Crane had fitted (http://www.rife.org/letters/571009marsh.jpg). This was for the specific purpose of setting the ray tube intensity as measured by a Heathkit PM-1 RF Power Meter. For the first time the carrier was variable, and Dr Stafford had a ham operator test it for him and found the tuning range was 2.4 – 4.68 MC (http://www.rife.org/letters/571112stafford+1.jpg). Sometime after that he noted in his report that the treatment range he used was 3.1 – 3.3 MC with a specific mention of the instrument specification being 3.1MC. His frequency meter was not capable of reading this frequency, so I believe he may have had the ham operator mark off on the dial the various frequencies. In 1958 independent lab reports show the carrier frequency to be set at 4.68 MC to accommodate the FCC and stay within the Marine Band, this is the time John Crane was getting the device ready for government use and it had to be standards compliant. In addition there were two types of ray tubes being used, the large round one, and the more compact one introduced to Dr Stafford in November 1958, the more compact one had a greater loading effect on the instrument and would also have shifted the frequency around. I believe Vern Thompson and the independent lab had the ability to measure RF frequency, but I doubt Johan Crane had any such instrument. A simple HF radio set would have sufficed, but it is never mentioned.

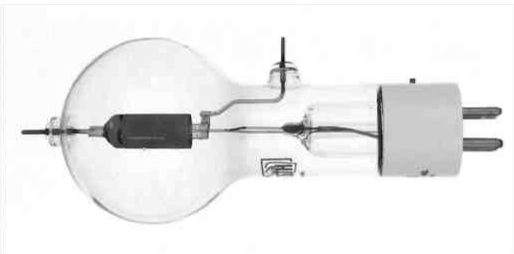
9 – 5 -1959 Stafford to Crane – Tektronix Oscilloscope Model 335-52

Instrument Output Voltages

18 Nov 1958 Discusses tests.

One unsolved anomaly of the AZ-58 is the vast range of claimed output voltages. Firstly the AZ-58 wiring diagram and the tube voltage table allude to a plate voltage in the region of 2,900 VDC and a plate transformer voltage of 3,500 VAC. The Lab test report (June 18th 1958) and AZ-Specifications talk of a measured output voltage of over 8000Vrms, 8250 Vrms to be exact. It was possible to measure this level of voltage using a Hewlett-Packard Model 410B Vacuum Tube Voltmeter fitted with a 1000-1 Model 452A probe. Another report 18 Nov 1958 Discusses tests done on the AZ-58 and it mentions the carrier being measured at 300Vrms with a HP Model 410B and probe. Now this is a voltage reading I can relate to as an ionised plasma tube has a lower impedance, and it is similar to readings I have taken of my replica AZ-58. Now the other readings must have been taken without a plasma tube attached, but even then the lab reports listed a ray tube as part of the test inventory. I have measured the open circuit voltage at around 2000Vp-p , and 8000Vrms will give a peak to peak voltage of around 11kV! I cannot substantiate how this level of voltage was present! Crane state " This involved a dual resonance balance. The balance of the carrier wave and the critical gas pressure gives proper emission" He may have happened upon a resonant situation where this level of voltage could be observed. The 812A RF Power Triode is only rated to a maximum plate voltage of 1500V.

The earlier measured tube readings are also a huge anomaly, which could be explained away if the data came from a much earlier instrument that possibly made use of another type of triode. James Cuningham had a theory it might have been a tube called the "EIMAC 75th" it had the same mounting base as the 809/812/812A and had a maximum plate voltage of 3,000VDC, data sheets go back to 1944. They were rumoured to be used in police transmitters in the era. Could this have been something Vern Thompson experimented with in the mid 40's and somehow John Crane had access to some of Vern Thompson's notes which he used in his 1973 patent application, as well as his 1958 Wiring Instructions. This could explain these high documented plate voltages. 



Another clue to higher voltage lies in the selection of filament transformers for the 816 rectifier tubes. 2 x RT102 – Triad F-3X were specified in the bill of material, having an insulation voltage of 3000V, where as a single 5V CT transformer rated at an insulation voltage 1500V would have done the job. I think if John Crane realised this the part would have been dropped to save on costs!. The RT101 - Merit C-3181 Filter Smoothing Choke also supports the 3000V insulation voltage over a more sensible value of 1500V.

In any case the listed plate transformer for the AZ-58 is RT105 is Merit P-3158 which only had a 1080-0-1080 Secondary winding well within the limits of normality. Then we have the anomaly of the wiring instructions calling for the 500-0-500 secondary to be wired in. I was quite prepared to dismiss the high voltage claims made by Crane but can't dispute the lab report measurements. The tuning capacitor used later on was the J.W. Miller 2112 10 - 365uF variable capacitor, it would never have handled such high voltages. The general spec of such capacitor having a 0.0125" spacing is 600V maximum. In fact there was discussion in the record of this capacitor arcing.

Another way to step up the output voltage would be to use another winding over or inside the tank coil; however there is no evidence in pictures to support this. We will have to assume that resonance is the cause of this anomaly, and seek out similar conditions in our replica devices.

Here is another theory as to the origin of higher voltages. Dr Yale had some students modify his instrument which Vern Thompson had to put right. In addition Dr Yale had 12 of his own instruments built, but operating on a much higher power. Could Vern Thompson have noted down these higher power modifications which crept in to the AZ-58 design ?
http://www.rife.org/letters/580321crane.jpg These instruments were called "Radex" and published a book "Radex the cure for cancer"

Az-58 Version 1 (1953)

(Fixed Hartley Osc.,Plate current, Square Wave Generator 50Hz – 6kHz, Range Switch 3 Band, Audio Freq. Dial, ? Fixed Tube Matching, Narrower Chassis 19")

Figure 12 AZ-58 Rife Frequency Instrument Dated 1953

This unit has a narrower chassis than other unit's, notice how the 19" front panel just covers the chassis. It is impressive looking and compact. Later units used a wider chassis that overlapped the 19" front panel, and dropped the shielding around the audio section, possibly due to there being more space available.

This instrument is dated in a photograph bearing the date September 1953, so it is reasonable to assume that was the year it made its first appearance. The plate current milliamp metre is visible and there is no evidence of the output tuning capacitor. It is also possible to make out the location of the plasma tube output tapping, being 15 – 16 turns from the front face plate. Also notice how the plasma tube terminals are given further insulation away from the face pate with a block of Bakelite. This would decrease capacitance of the feed through connector and raise arc over levels.

Notice the tuning capacitor sits on top of a Perspex plate with a rectangular cut-out in the chassis just below it.

AZ-58 Version 2 (#5)

(Fixed Hartley Osc. , Plate Current Meter, Square Wave Generator 50Hz – 6kHz, Range Switch 3 Band, Audio Freq. Dial Vernier, ? Fixed Tube Matching, Wider Chassis)

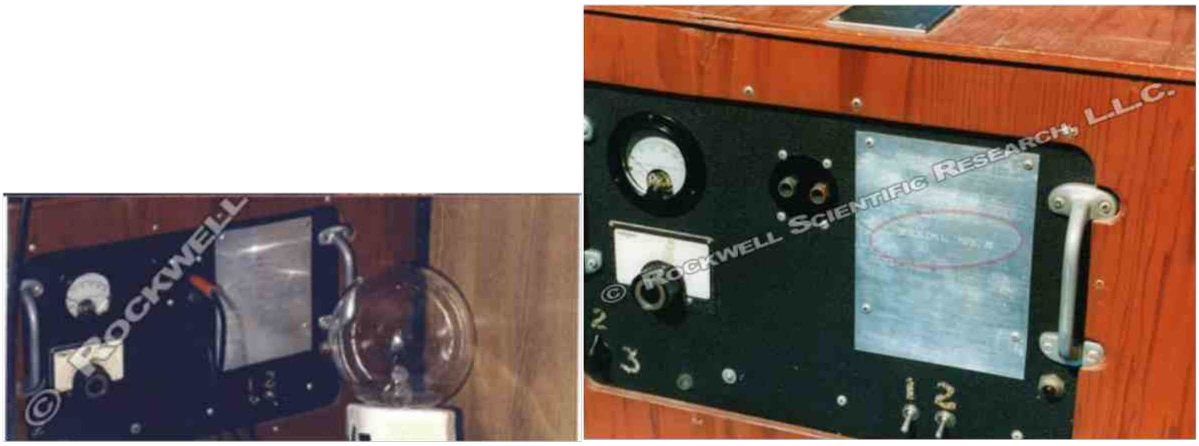


Figure 13 AZ-58 Number 5 - Rockwell Instrument

This is the #5 Instrument currently with the Rockwell Foundation. It still has a mili-ampmeter. It incorporates the newer wider case, but a more rounded front aperture. The National ACN dial face is featured.

AZ-58 Version 3

(Fixed Hartley Osc. , Square Wave Generator 50Hz – 6kHz, ?? Range Switch 3 Band, Audio Freq. Dial Verier, Fixed Tube Matching, Wider Chassis 22”)

.

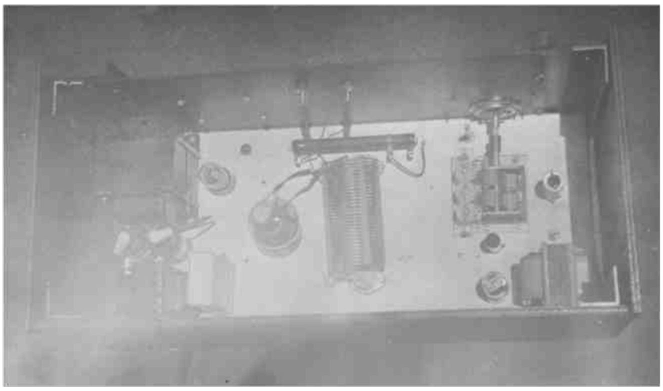


Figure 14 Early Vern Thompson Device

This instrument is clearly in the same chassis style of the later AZ-58’s, and the three trimmer capacitors can be seen next to the audio tuning capacitor, this is in accordance with the AZ-58 wiring instructions, as well as the Perspex insulation plate under the AF capacitor. The fixed pre-set wire wound resistor used for tube matching is clearly visible. The mA Plate Current meter is not there neither is there any cut-out for it. The later production run had cut-outs for the meter which when no meter was installed was blanked off. The wider chassis might have been employed to gain physical separation distance between the RF and AF stages in an attempt to make the AF stage more stable.

AZ-58 Version 4 (Dr Stafford-1957)

(Variable Hartley Osc. , Square Wave Generator 50Hz – 6kHz, Range Switch 3 Band, Audio Freq. Dial Vernier, Fixed Tube Matching, Wider Chassis 22")

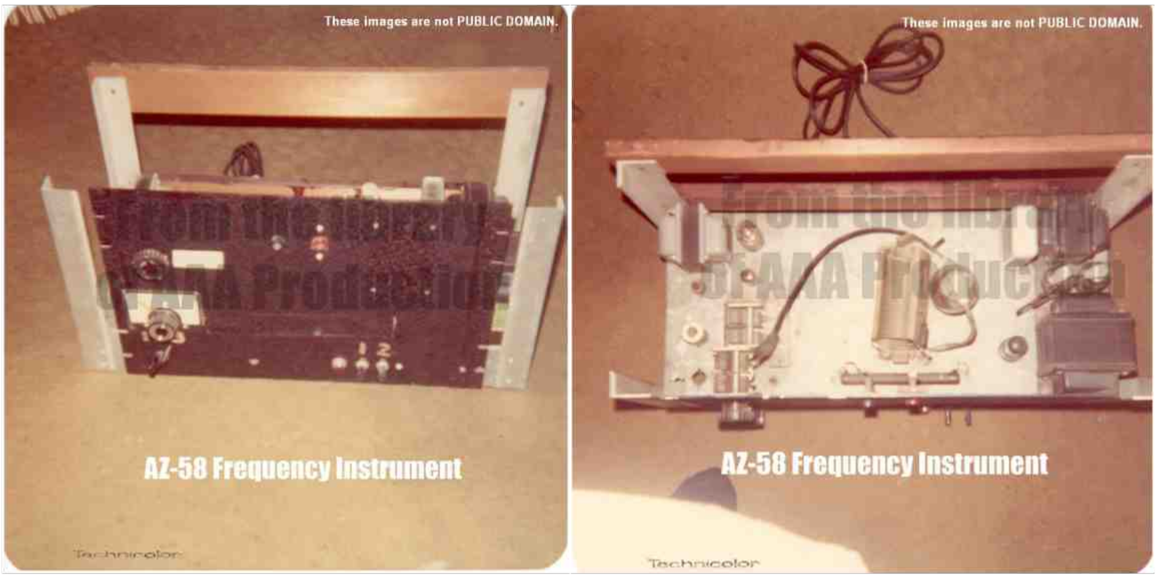


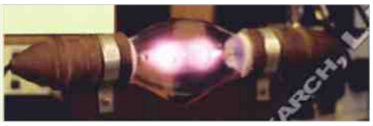
Figure 15 Dr Staffords instrument, Marsh Collection

Dr Staffords device incorporated all the modifications, tube matching and carrier frequency control. It is rather strange to mount the intensity capacitor just above the AF capacitor, as this would introduce interference in the circuit, not to mention the long piece of wire linking it to the tank coil.

AZ-58 is used in conjunction with an external frequency counter to help stabilise the output frequencies, as well as a power meter to help optimise the positioning of the ray tube. There are numerous letters between John Crane and Dr Stafford that cover some aspects of the machine operation and calibration, as well as documented clinical results. This is well documented in a report "Electromagnetic Field Therapy (EFT) – Robert P Stafford, M.D. – April 1963". In addition Dr Stafford had various aspects of the device measured over the years, as well as experimented with the large and more compact Ray tubes; the compact tube had lower impedance which caused the device to fail on one occasion.

The carrier intensity dial was able to adjust through a range of 2.4 to 4.68 MCPS. Dr Staffords report lists a used carrier range of 3100 to 3300 KCPS, along with his preferred protocol of (728-784-880-2008-2128) it is important to note that Dr Stafford had no way of calibrating the carrier frequency setting. At one stage he had a radio ham test it (Letter from Stafford to Marsh dated 12 Nov 1957), and may have recorded the dial settings. The way to set the carrier was to vary it for maximum intensity measured with the power meter and leave it be.

In July 1959 Crane issued a directive to have half the ray tube painted with 5 coats of aluminium paint, to form a reflector behind the beam. This was due to complaints that the old larger tube was more effective. (Of course different impedance means different matching and high SWR's could have resulted in less radiated power coming out of the ray tube)



2. The circuit is a variable audio function generator modulated on a variable frequency transmitter by placing a tuning capacitor in the circuit between the main power coil and the ray tube to tune the resonance of the circuit and make the color intensity of the helium gas to be variable. Almost any air gap tuning capacitor will function well. Now we are using a more sophisticated tuning wattmeter with a range of 0 to 3,000 watts. In some of the early ray tube instruments the frequency given for the carrier wave was in the attempt to reach 10 MHz but the frequency to devitalize the cancer virus was 2128. Rife's story about a "wide range of waves" applied to the audio frequencies which were tuned to the full range of audio frequencies at times by other doctors in the hope that some other frequency might be resonant and dev-italize the body's problems with microorganisms. Further research will discover the best carrier frequency and not what the FCC allows in order to provide suppression for the A.M.A. gang.

3. The carrier is a fixed frequency usually crystal controlled in order to attain the desired frequency specified by the FCC. As stated before the variation came from a tuning capacitor that I added later in 1954. Rife did not have it and never used it to my knowledge.

Letter to Rick Sheppard from Crane 18 November 1988

http://www.rife.org/crane/jc11-5-58.jpg Intensity and calibration

http://www.rife.org/letters/590712crane+2.jpg Painting the new tube

http://www.rife.org/letters/581022crane.jpg - Using the PM-1 Power Meter, Intensity Setting, tube handles

http://www.rife.org/letters/581105crane+rife.jpg Field Calibration

http://www.rife.org/letters/580819crane.jpg New Electronic engineer to redesign circuits and new tubes

In a letter to Dr Stafford November 1958 – Crane Report PG 18A

To answer the question about ultraviolet light from the new or old bulb; An analysis of this light was made witha Hilger F-4 quartz spectrograph which indicated the light and the production thereof to be in the visible region of from 4000 A to 6500Ø Angstroms. The ultra violet extends from 4000 A on down to 2000 A and that is where our chart ends. Some slight overlap may occur in the 4000 A area but it would be so slight that I doubt if any effect would be noticeable. Only ordinary visible light is emmitted due to the gas discharge in the tube. The RF has been rated at 330 volts using a Hewlett Packard model 410B, with a model 453A R.F. capacity divide having a 100 to 1 ratio; the impedance without the divider is 10 megohms (D.C.); with the capacity divider it is 100X greater. No loading of the instrument occurs due to this measurement, as judged by a lack of detectable change of audio-output in a radio receiver. No x-rays or ionizi radiation are emitted by the tube while the discharge is taking place. These measurements have been made close to the glass envelope of the tube both with a nuclear model 2611 Geiger-Muller Survey Meter, as well as a sensitive Lauritsen electroscope of the integrating type. No radiation above background was detect///ed by either of these two instruments.

Hewlett-Packard 521-A Frequency Counter

On the recommendation of John Crane Dr Stafford acquired a Hewlett-Packard 521-A Frequency Counter.

This device came out in 1954, and the default model used the 60 hz mains frequency as a signal source. This device had a measurement range of 1 to 120,000 CPS

-hp-

MODEL 521A INDUSTRIAL ELECTRONIC COUNTER

RANGE: 1 cps to 120 kc.

ACCURACY: ±1 count ± accuracy of timing frequency. (Approximately ±0.1% when power line used, ±0.01% with crystal standard installed.)

REGISTRATION: 4 places. Total count capacity 9,999.

INPUT REQUIREMENTS: 0.2 v rms minimum or output from 1P41 Phototube (or equal). Phototube bias provided at "PHOTOTUBE" jack.

INPUT ATTENUATOR: Adjusts sensitivity from 0.2 v to 100 v rms to overcome noise.

INPUT IMPEDANCE: Approximately 1 MΩ, 50 μμf shunt (500 KΩ on "PHOTOTUBE" jack).

SPECIFICATIONS

GATE TIME: 1/10 and 1 second. Panel neon lamp indicates that gate is open.

MANUAL GATE: Controlled by "Open-Closed" switch or external contacts.

DISPLAY TIME: Variable from 1/10 to 15 seconds; or display can be held indefinitely.

READS IN: Cps or directly in rps or rpm with -hp- 506A or 508A/B Tachometer Accessories.

SELF-CHECK: Counts 60 cps line frequency (or 10 kc with optional plug-in oscillator) for any selected gate time.

EXTERNAL STANDARD: Can be operated from any multiple of 10 cps, 10 cps to 100 cps.

PHOTOTUBE INPUT: Supply voltage for 1P41 (or equal) phototube provided at phone jack on rear.

ACCESSORY SOCKET: At rear; supplies 6.3 v ac, 0.6 a; +300 v dc, 10 ma; −150 v dc, 5 ma.

CONNECTORS: BNC and std. phone jacks.

POWER SUPPLY: 115 v ±10%, 50/60 cps, 170 watts.

SIZE: Cabinet Mount: 9¾" wide, 13⅞" high, 13⅜" deep.

WEIGHT: Cabinet Mount: 28 lbs. net; shipping weight 37 lbs.

ACCESSORIES PROVIDED: 1 each -hp- AC-16D Cable Assembly, 44" RG-58/U cable terminated one end with UG-88/U Type BNC connector.

ACCESSORIES AVAILABLE: -hp- Model 506A Optical Tachometer Pickup, $100.00. -hp- Model 508A/B Tachometer Generator, $100.00. -hp- 521A-59B Crystal Controlled Time Base (plug-in unit), $100.00.

PRICE: -hp- Model 521A Industrial Electronic Counter, Cabinet Mount, $475.00. -hp- Model 521A Industrial Electronic Counter, Cabinet Mount, with -hp- 521A-59B Crystal Controlled Time Base, $575.00. For rack mount model, add $5.00 to these prices.

All prices f.o.b. Palo Alto, California
Data subject to change without notice.

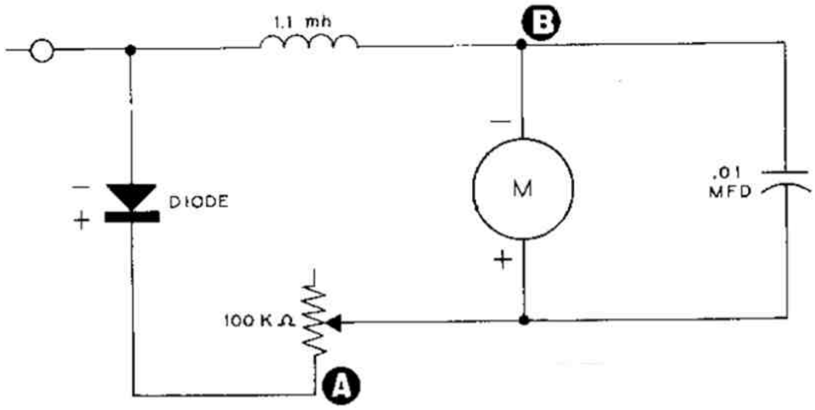
So on a reading of 2,000Hz +- 0.1% gives us an error margin of 4 Hz in readings. We must remember this when dealing with these quoted frequencies.

Heathkit PM-1 RF Power Meter

In order to orientate the Ray Tube correctly Crane recommended a Heathkit PM-1 RF (relative) Power Meter be used. It is a fairly simple device and could readily be built. Crane instructed that the antenna was to be removed before it was used.

The Heathkit RF Power Meter Kit is designed to sample the RF field in the vicinity of your transmitter, whether it be marine, mobile, or fixed. It requires no batteries, electricity, or direct connection to the transmitter. The power meter is merely placed in some location close to the transmitter, to pick up RF radiation from the antenna which is then indicated on a panel meter. It provides you with a continuous indication of transmitter operation. You can easily detect if power is dropping off by comparing present meter readings with past ones.

The PM-1 operates with any transmitter having output frequencies between 100 kc and 250 megacycles, regardless of power. Sensitivity is 0.3 volts RMS full scale, and a special control on the panel allows for further adjustment of sensitivity. The meter is a 200 ua unit, mounted on a chrome-plated brass panel. Housed in a plastic case the entire PM-1 measures only 3¾" W. x 6¼" H. x 2" D. An easy way to put your mind at ease concerning transmitter operation.



SCHEMATIC DIAGRAM
Heathkit Mobile Tuning Meter Model PM-2

Hewlett-Packard Model 410B Vacuum Tube Voltmeter

This could read RF voltages and with a 1000-1 Model 452A probe was capable of measuring high RF voltages.

Figure 9. -hp- Model 452A Divider p mits measurement of voltages up to 25 kv a-c.

Figure 10. -hp- Model 453A Divider permits measurement of voltages up to 2000 volts a-c.

SPECIFICATIONS:

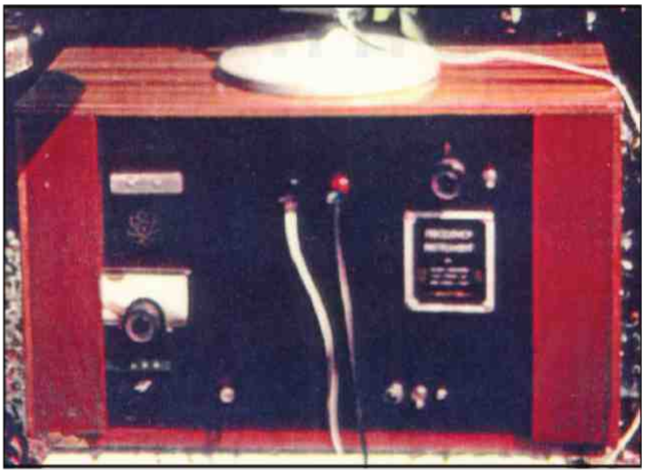
Ranges: 1 to 300 volts full scale in 6 ranges: 1, 3, 10, 30, 100, and 300 volts AC or DC and 0-1000 volt range DC. Resistance 0.2 ohm to 500 megohms in seven ranges. Mid-scale reading of 10, 100, 1, 000, 10,000,100, 000 ohms, 1 megohm, and 10 megohms.

Accuracy: ±3% of full scale on all ranges on sinusoidal AC voltages and DC voltages. The AC portion of the instrument is a peak-reading device, calibrated in rms volts. Ohmmeter accuracy is ±1 ohm at mid-scale of RX1 range, ±5% at mid-scale of all other ranges.

Frequency Response: Frequency response is flat within ±1 db up to 700 me and drops off less than 1 db at 20 cps. Probe resonant frequency is about 1, 250 mc and an indication can be obtained up to 3,000 mc.

AZ-58 Version 5

(Variable Hartley Osc. , Square Wave Generator 50Hz – 6kHz, Range Switch 3 Band, Audio Freq. Dial Vernier, ? Fixed Tube Matching, Wider Chassis 22”, Additional Dial + Switch RHS Top corner)



This instrument has what appears to be the carrier frequency dial just under the blanked off ammeter plate, as is the customary location, but that appears not to be the case and may just be a cover. The frequency tuning knob appears to have moved to the right hand side. This correspondence from John Crane clears that up: http://www.rife.org/letters/581022crane.jpg

There is also a toggle switch next to this tuning knob. One of the lower Filament or HV toggle switches appears to have moved here. Most likely the HV one as that is the general location of the plate transformer.

This is the device that Crane talked about fitting a reflector to his ray tube.

AZ-58 Version 6 (1958)

(Variable Hartley Osc. , Square Wave Generator 50Hz – 6kHz, Range Switch 5 Band, Audio Freq. Dial Vernier , New Aluminium Cabinet 19”)

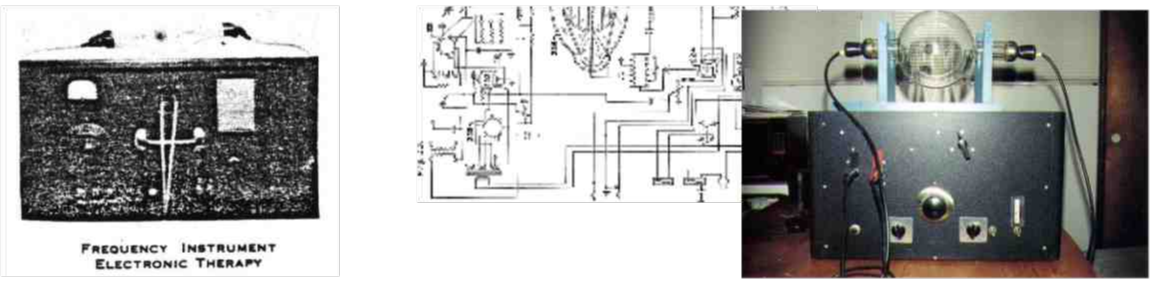


Figure 16 Picture from a 1957 Life Labs letter head

CASE MOCKUP

This is the device as described in the only circuit diagram we have of the AZ-58 dated 1958 and is also the device described in the Crane 1973 patent application. The picture does not necessarily go with the period, as it has an ammeter and a round frequency dial. The true AZ-58 (1958) instrument as described in the John crane schematic diagram has a number of anomalies which have already been highlighted. It is possibly the culmination of all the years of development since 1953. One notable item that is missing is the tube matching resistor! Did John crane assume that the intensity (High KC) knob would suffice? This might have been an incorrect assumption brought about by comparing results from the PM-1 power meter, and determining that matching was superfluous, this was a Vern Thompson inclusion, and he being a radio man would know what it was for. John Crane would have been ignorant of this and dropped it to save on cost believing the intensity/carrier knob would do the same function. Interestingly John Marsh in his 70's instrument included antenna matching and power/SWR measurement.

The 1958 year saw a lot of official LAB testing of the now named AZ-58 for X Ray emissions and electrical safety. We now for the first time see the mention of the 4.68 MC carrier which would have been FCC compliant.

From examining the AZ-58 component list we realize this instrument was planned to have an off the shelf aluminium case, possibly entirely sourced from Bud Industries. This would have looked more professional and saved on labour to build a wooden case, as well as helped with screening. See the component analysis section for some more details.

In May 1958 Crane claimed to be building a new instrument for Dr Jeppson, steel cabinet on casters, air cooled from the base, 1 cps stability, cost $7000 – Could this be the design input in to that device ? http://www.rife.org/letters/580521crane.jpg

TEST REPORTS

AZ-58 Version 7

New instrument, crystal controlled with one switch will emit 10 frequencies on a carrier at the same time. This was discussed, and finaly built by John Marsh. (PIC)

http://www.rife.org/letters/591114crane.jpg

Original Components

We are fortunate to have the original component list of the AZ-58 and from it we can piece together bits of information not available on the drawings.

FREQUENCY INSTRUMENT

PARTS LIST

Life Lab, Inc.
4246 PEPPER DRIVE
SAN DIEGO 5, CALIF.

Page 1

When ordering replacement parts, be sure to specify the part number shown below. Equivalent parts may be substituted.

Part No.	Parts Per Kit	Vendors No.	Approved Vendor	Description
RT101	1	C-3181	Merit	Filter smoothing choke
RT102	2	P-3X	Triad	Filament transformer
RT103	1	P-2947	Merit	Filament transformer
RT104	1	R-9A	Triad	Power transformer
RT105	1	P-3158	Merit	Plate transformer
RT106	1	C-2995	Merit	8 Hy 100 Ma Choke 3750
C101	1	YFM-31	Sprague	.0001 1200 volt mica
C102	2	BFC-12	Hammarlund	variable capacitor
C103	1	YFM-25	Sprague	.005 1200 volt mica
C104	2	R-154-U	National Co	RF Choke
C105	2	C-220	Sangamo	.002 1500 volt mica
C106	2	Budroc	Cornell Dub'r.	.5mfd 600 Volts D.C.
C107	1	PT-615	Mallory	.05 mfd 600 Volts D.C.
C108	1	PT-6025	Mallory	.25 mfd 600 Volts D.C.
C109	1	PT-412	Mallory	.02 mfd 400 Volts D.C.
C110	2	TC-72	Mallory	10 mfd 450 Volts D.C.
C111	1	3304C1	Sangamo	.1 mfd 400 Volts D.C.
C112	2	TJU-15020J	Cornell Dub'r	2.0 mfd 1500 Volts DC
C113	1	7825-5	Miller	5 amps Line filter choke
C114	1	U29	Mallory	25M ohms Midgetrol
C115	1	U48	Mallory	500M ohms Midgetrol
C116	1	TC-32	Mallory	10 mfd 60 Volts D.C.
R101	3	Little Devil	Ohmite 2W	1800 ohm resister 10%
R102	2	Carbon	Dalohm ½W	200K ohm resistor 1%
R103	2	Carbon	Dalohm ½W	1 Megohm resistor 1%
R104	2	Carbon	Dalohm ½W	2 Megohm resistor 1%
R105	2	Carbon	Dalohm ½W	10 Megohm resistor 1%
R106	2	Carbon	Dalohm ½W	20 Megohm resistor 1%
R107	1	Little Devil	Ohmite 1W	39K ohm resistor 10%
R108	1	Little Devil	Ohmite 2W	47K ohm resistor 10%
R109	1	0965	Ohmite 25W	10,000 ohm resister Adj.
R110	1	Brown Devil	Ohmite 10W	10,000 ohm resistor
R111	1	Little Devil	Ohmite ½W	3 Megohm resister 10%
R112	1	Little Devil	Ohmite ½W	220K ohm resistor 10%
R113	1	0377	Ohmite 25W	2000 ohm resistor adj.
T101	2	816	RCA	Tube
T102	1	12AT7	RCA	Tube
T103	1	6AQ5	G.E.	Tube
T104	1	6X5 GT	G.E.	Tube
T105	1	812A	RCA	Tube
T106	1	Ray tube	San Diego Scientific Glass Apparatus Co.	Tube

Figure 17 From http://www.rife.org/az58/az58.html

FREQUENCY INSTRUMENT
PARTS LIST CONTINUED

Life Lab, Inc.
4245 PEPPER DRIVE
SAN DIEGO 5, CALIF.

(2) Page 2

Part No.	Parts Per Kit	Vendors No.	Approved Vendor	Description
S101	2	SPST	Arrow	Toggle switch 5 amp 250V
S102	1	PA-1002	Centralab	2 Pole 5 Pos switch rotary shorting phenolic
S103	1	365	Mallory	Knob
S104	1	380	Mallory	Dial Plate 1 to 5
S105	1	HRT	National	Knob
S106	1	ACN	National	Dial 0 to 100
S107	2	2112	Miller	Variable condenser
S108	1	39003	Millen	Coupling
S109	1	¼"dia.	Stock	Plastic rod x ¼" Lg.
S110	1	APC-25	Hammarlund	Capacitor
S111	1	¼x.87	Plexiglas Stock	Plate x 4" Lg.
S112	1	¼ x 3¼"	Plexiglas Stock	Plate x 4" Lg.
S113	3	3 watt	G.E.	120 Volt lamp
S114	1	#46 .25 amp	Tung Sol	6 Volt blue bead screw
H101	1	810M-431	Dialco	Bayonet base for lamp
H102	2	MDV 125V	Fusetron 7 amp	Fuse slow blow type
H103	2	HKP	Fusetron	Panel mtd. fuse holder
H104	2	392B	Birnbach (red & blk)	Insul. giant plug
H105	1	393	Birnbach	Insul. giant jack red
H106	1	393	Birnbach	Insul. giant jack black
H107	1	257	Birnbach	Jack open 2 conductor
H108	1	A2A	Mallory	Jack circuit closing
H109	1	815	Birnbach	6' safety cord
H110	1	813	Birnbach	Male AC interlock plug
H111	1	1382A	Birnbach	Lug terminal strip
H112	3	109CH	Drake	Min. scr. light base
H113	2	478	Birnbach	Feedthru Insulator
H114	2	867	Birnbach	Corrugated insulator
H115	1	9S2	Cinch-Jones	Tube shield
H116	1	9XM	Cinch-Jones	9 pin shield base socket
H117	1	7BM	Cinch-Jones	7 pin bottom mounted
H118	1	49RSS8	Amphenol	8 pin octal S type socket
H119	3	49RSS4	Amphenol	4 pin S type socket
H120	1	3906-1	Barker & Williamson	Air Inductor X 4½" Lg.
H121	1	AC-416	Bud	Chassis - aluminum
H122	1	C-1552	Bud	Cabinet - aluminum
H123	1	PA-1108-B	Bud	Rack panel 1/8" aluminum
H124	2	1382B	Birnbach	Lug terminal strip
H125	1	½"dia.	Plexiglas	X 1" Lg. Drill one end, & bore .40 x 15/16 deep.
H126	2	36002	Millen	Ceramic grid cap. 3/8
H127	1	36001	Millen	Ceramic grid cap 9/16
H128	6	NO. 4	Walsco	Vinyl grommet for 1/2" hole.
H129	1	717 NE-T2	General Cement	Neon glow lamp.
H130	1	Shielding	Aluminum	.04 x 8 x 10" lg.

Transformers and Chokes

I have managed to find specifications on all the transformers, including evidence that supports the higher B+ voltage of 2700VDC mentioned in the Crane 1973 patent application and AZ-58 Wiring Instructions.

RT101 - Merit C-3181 Filter Smoothing Choke 10H 200mA 140 Ohm

It is interesting to not this choke has a 3000V Insulation voltage, instead of a more common 1500V. This again supports a higher plate voltage of 2700V being used in the development history of this instrument.

FILTER CHOKES
For Small Transmitter and Amplifier Applications

Type No.	List Price	Inductance Henries	Current Rating M.A.	DC Res. Ohms	Volts Insul.	Dimensions H.	W.	D.	Mtg.
C-3192	$5.00	15	85	325	1500	3¼	2⅝	2⅝	D
C-3193	5.00	10	110	200	1500	3¼	2⅝	2⅝	D
C-3194	6.00	12	150	230	1500	3½	2 15/16	3⅛	D
C-3195	8.75	15	150	180	2000	3⅞	3 3/16	3⅜	D
C-3196	7.00	5	200	80	1500	3½	2 15/16	3⅛	D

FILTER SMOOTHING CHOKES
For Transmitter Power Supplies

Type No.	List Price	Inductance Henries	Current Rating M.A.	DC Res. Ohms	Volts Insul.	H.	W.	D.	Mtg.
C-3180	$ 6.50	10	150	210	3000	3⅛	2⅝	2¾	D
C-3181	8.00	10	200	140	3000	3½	2 15/16	3½	D
C-3182	11.00	10	250	125	3000	3⅞	3 3/16	3¾	D
C-3183	11.50	8	300	80	3000	3⅞	3 3/16	3¾	D

RT102 – Triad F-3X (P-3X?)

This transformer is incorrectly labelled filament transformers start with an F not a P and X refers to the case style. It is noteworthy that a quantity of 2x were specified, as the 816 Rectifier tubes require 2.5V AC at 2A, a 2.5V CT transformer can only deliver 1.25-0-1.25 so toe power both rectifiers two transformers were required. These transformers have a 3000V insulation voltage which was possibly far more attractive than the F-7X 5V CT at 1500V which could have done the job in a single package. This to seems to be a throwback to a much higher plate voltage od 2700V DC being used in the instruments development history.

FILAMENT Transformers
Single Secondary Winding

Type No.	Secondary Volts	Amperes	Test Volts	Dim.-Inches H	W	D	Wt. Lbs.
F-1X	2.5 C.T.	3	1500	1 11/16	2 11/16	1½	⅝
F-3X	2.5 C.T.	10	3000	2¼	3 1/16	2¼	1¾
F-5U	2.5 C.T.	10	7500	3 1/16	2½	2½	2
F-7X	5 C.T.	3	1500	1 11/16	3¼	1⅞	1¼
F-9U	5.2 C.T.	13	1500	3⅜	2 11/16	3	3½
F-11U	5.2 C.T.	24	1500	3¾	3⅛	3¼	5½
F-14X	6.3 C.T.	1.2	1500	1 11/16	2 11/16	1½	⅝
F-16X	6.3 C.T.	3	1500	1 15/16	3¼	1⅞	1¼
F-18A	6.3 C.T.	6	1500	3 1/16	2⅝	2⅜	2¼
F-21A	6.3 C.T.	10	1500	3 5/16	3	3⅜	3½
F-23U	10 C.T.	7	1500	3 5/16	3	3⅝	4
*F-40X	24	1	1500	1 15/16	3¼	2	1¼

*New Item

CASE X

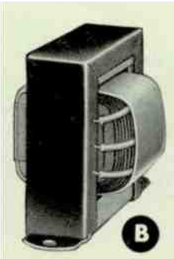
Figure 18 Triad Catalogue 1951 Page 11

RT103 - P2947 Filament Transformer

This is the filament transformer for the 812A Triode. It is interesting how the centre tap is not used contrary to accepted practice at the time.

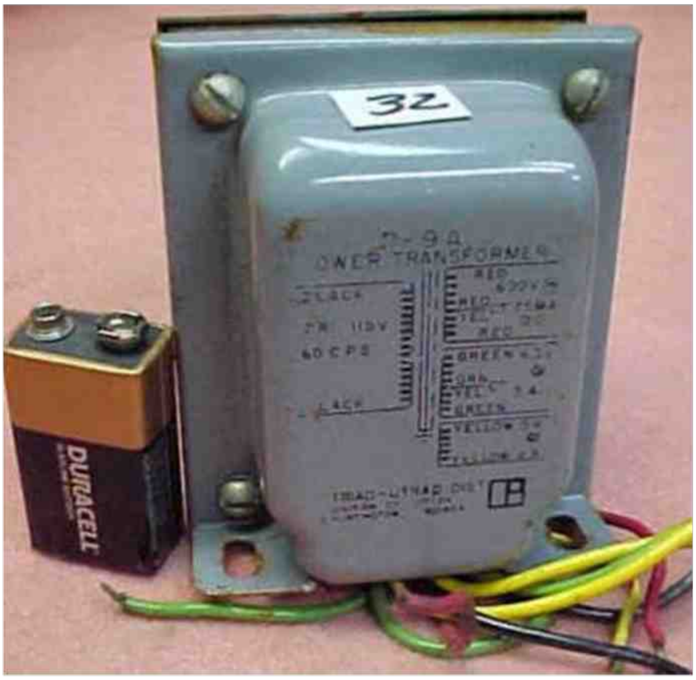
FILAMENT TRANSFORMERS
For Amplifier, Amateur, Industrial Use. Pri. 115 Volts, 60 Cycles

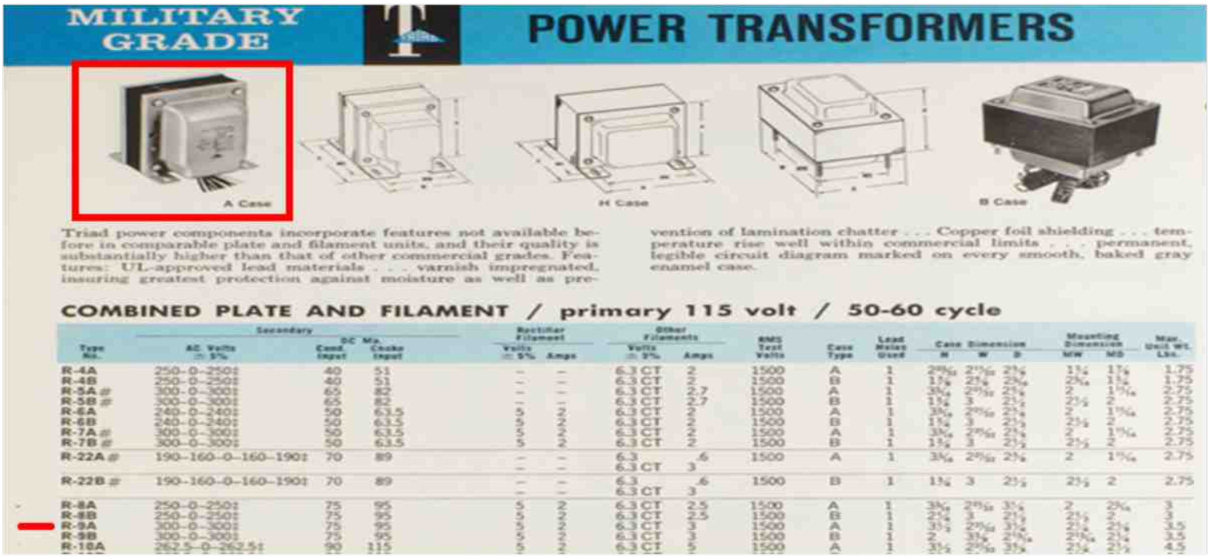
Type No.	List Price	Sec. Volts	Sec. Amp.	Insulation Volts	Dimensions H.	Dimensions W.	Dimensions D.	Mtg.
P-2939	$ 3.75	2.5 c.t.	5	2500	2	3¼	1⅝	A
P-2940	5.75	2.5 c.t.	10	7500	3	3⅝	2¼	B
P-3042	6.25	2.5 c.t.	10	10000	2⅞	3⅜	2¼	EH
P-3040	4.25	5 c.t.	3	2500	2	3¼	2⅛	A
P-2941	5.00	5 c.t.	6	2500	2¼	3 11/16	1⅞	A
P-2942	6.90	5 c.t.	12	2500	3 7/16	2 13/16	2⅜	EV
P-2943	11.00	5 c.t.	20	2500	3¾	3⅛	3	EV
P-2944	2.80	6.3 c.t.	1	2500	1⅝	2 13/16	1½	A
★P-3074	3.60	6.3	1.2	3500	2	3¼	1⅝	A
P-2945	3.60	6.3 c.t.	2	2500	2	3¼	1⅝	A
P-2946	4.25	6.3 c.t.	3	2500	2	3¼	1⅞	A
P-2947	5.50	6.3 c.t.	6	2500	3	3⅝	2¼	B



RT104 – TRIAD R-9A Plate / Filament Transformer

This was the power transformer used to power the audio frequency generator stage.





Triad power components incorporate features not available before in comparable plate and filament units, and their quality is substantially higher than that of other commercial grades. Features: UL-approved lead materials . . . varnish impregnated, insuring greatest protection against moisture as well as prevention of lamination chatter . . . Copper foil shielding . . . temperature rise well within commercial limits . . . permanent, legible circuit diagram marked on every smooth, baked gray enamel case.

COMBINED PLATE AND FILAMENT / primary 115 volt / 50-60 cycle

Type No.	Secondary AC Volts ± 5%	DC Ma. Cond. Input	DC Ma. Choke Input	Rectifier Filament Volts ± 5%	Rectifier Filament Amps	Other Filaments Volts ± 5%	Other Filaments Amps	RMS Test Volts	Case Type	Lead Holes Used	Case Dimension H	Case Dimension W	Case Dimension D	Mounting Dimension MW	Mounting Dimension MD	Max. Unit Wt. Lbs.
R-4A	250-0-250‡	40	51	–	–	6.3 CT	2	1500	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.75
R-4B	250-0-250‡	40	51	–	–	6.3 CT	2	1500	B	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.75
R-5A #	300-0-300‡	65	82	–	–	6.3 CT	2.7	1500	A	1	[illegible]	[illegible]	[illegible]	2	[illegible]	2.75
R-5B #	300-0-300‡	65	82	–	–	6.3 CT	2.7	1500	B	1	[illegible]	3	2½	2½	2	2.75
R-6A	240-0-240‡	50	63.5	5	2	6.3 CT	2	1500	A	1	[illegible]	[illegible]	[illegible]	2	[illegible]	2.75
R-6B	240-0-240‡	50	63.5	5	2	6.3 CT	2	1500	B	1	[illegible]	3	2½	2½	2	2.75
R-7A #	300-0-300‡	50	63.5	5	2	6.3 CT	2	1500	A	1	[illegible]	[illegible]	[illegible]	2	[illegible]	2.75
R-7B #	300-0-300‡	50	63.5	5	2	6.3 CT	2	1500	B	1	[illegible]	3	2½	2½	2	2.75
R-22A #	190-160-0-160-190‡	70	89	– –	– –	6.3 6.3 CT	.6 3	1500	A	1	[illegible]	[illegible]	[illegible]	2	[illegible]	2.75
R-22B #	190-160-0-160-190‡	70	89	– –	– –	6.3 6.3 CT	.6 3	1500	B	1	[illegible]	3	2½	2½	2	2.75
R-8A	250-0-250‡	75	95	5	2	6.3 CT	2.5	1500	A	1	[illegible]	[illegible]	[illegible]	2	[illegible]	3
R-8B	250-0-250‡	75	95	5	2	6.3 CT	2.5	1500	B	1	[illegible]	3	2½	2½	2	3
R-9A	300-0-300‡	75	95	5	2	6.3 CT	3	1500	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.5
R-9B	300-0-300‡	75	95	5	2	6.3 CT	3	1500	B	1	2	[illegible]	[illegible]	[illegible]	[illegible]	3.5
R-10A	262.5-0-262.5‡	90	115	5	2	6.3 CT	5	1500	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.5

Figure 19 Triad 1951 Catalogue

TRIAD R-9A POWER TRANSFORMER , Combined Plate and Filament, General Purpose

- PR) 115 VAC 60 HZ 1 PH
- S1) 600CT @ 75MA (600-0-600)
- S2) 5 VAC @ 2A
- S3) 6.3 VAC CT @ 3A (3.15-0-3.15)
- DM) HT = 3.25 WT = 3 DT = 3.25 MD = 4.125 MW = 3.500 WEIGHT)

RT-105 - Merit P-3158 Plate Transformer

This was used to form the 1000V B+ voltage used by the Hartley Oscillator in the MOPA output stage.

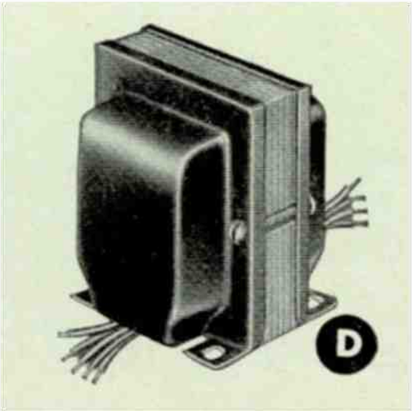
PLATE TRANSFORMERS

For Small Transmitters. DC Voltage Ratings are Approx. Values Obtained at Output of a 2 Section Choke Input Filter Using Mercury Vapor Rectifier Tubes. Pri. is for 115 V. 60 cy.

Type No.	List Price	Sec. Rms. Volts	Sec. DC Volts	DC Sec. M.A.	Dimensions H.	Dimensions W.	Dimensions D.	Mtg.
P-3175	$10.50	550-550	400	150	3 9/16	3	3 7/8	D
P-3157	13.75	660-660 † / 550-550	500 / 400	250	4 5/8	3 13/16	4 3/8	D
P-3158	17.00	1080-1080 / 500-500	1000 ‡ / 400	125 / 150	4 5/8	3 13/16	5	D
P-3159	16.50	900-900 / 800-800	750 / 600	225	4 5/8	3 13/16	5 1/8	D
P-3167	41.00	1450-1450 / 1175-1175	1200 / 1000	300	5 3/4	6 1/8	4	EH
P-3168	52.00	2100-2100 / 1800-1800	1750 / 1500	300	5 3/4	6 1/8	4 1/2	EH
P-4062	80.00	2900-2900 / 2385-2385	2500 / 2000	300	8 1/2	6 1/2	5 5/8	H

†Has 40-volt bias tap.
‡For dual operation with simultaneous use of both sec. ratings.

Figure 20 Merit Transformer Catalogue 5111 (February 1951)



From this we know the HV was derived from the 1080-0-1080 winding, and the 500-0-500 winding was left unconnected.

RT106 – Choke Merit C-2995 8H 100mA

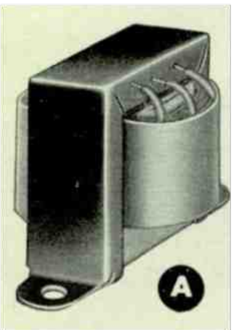
REPLACEMENT TYPE FILTER CHOKES

Inductance Ratings are at 10 V. 60 cy. with Rated Current Flowing as Recommended by the R.M.A.

Type No.	List Price	Inductance Henries	Current Rating M.A.	DC Res. Ohms	Volts Insul.	Mtg. Centers	Dimensions H.	Dimensions W.	Dimensions D.	Mtg.
★C-2973	$1.55	1.5	10	95	1500	1 3/4	1 5/16	1 7/16	1	A
★C-2994	2.00	1.5	200	90	1500	2 3/8	1 5/8	2 13/16	1 5/8	A
C-2974	3.85	2.0	200	50	1500	2 13/16	2	3 1/4	1 5/8	A
C-2977	2.20	4.5	50	200	1500	2 3/8	1 5/8	2 13/16	1 1/2	A
C-2975	1.80	5.5	50	330	1500	2	1 5/16	2 3/8	1 5/8	A
C-2976	1.80	8	40	500	1500	2	1 3/8	2 3/8	1 1/4	A
★C-2995	2.75	8.0	100	375	1500	2 13/16	2	3 1/4	1 5/8	A
C-2981	2.20	8.5	50	400	1500	2 3/8	1 5/8	2 13/16	1 1/2	A
C-2985	2.20	20	15	900	1500	2 3/8	1 5/8	2 13/16	1 1/2	A
C-2987	2.50	16	50	550	1500	2 13/16	2	3 1/4	1 5/8	A
C-2990	3.30	15	75	400	1500	3 1/8	2 1/4	3 11/16	2 1/8	A
★C-2991	4.40	2	250	53	2000	3 5/16	2 5/16	3 11/16	2	A
C-2993	4.40	10.5	110	220	1500	3 5/16	2 5/16	4	2 1/4	A
★C-2996	3.30	1.0	300	60	1500	3 1/8	2 1/4	3 11/16	2	A

★Indicates TV Replacements.

Figure 21 Merit 1951 Catalogue page 4



C104 - R-154-U National Plate Choke

1mH 600ma

Used as the plate and grid chokes on the 812A triode. At frequency its function is to act like a resistor and block AC signals and only let DC current through.

R-154U List $

For the 20, 40 and 80 meter bands. Inductance 1 m.h., DC resistance 6 ohms, DC current 600 ma. Coils honeycomb wound on Isolantite core. The R-154U does not have the third mounting foot and the small insulator, but is otherwise the same as R-154. See illustration.

Variable Capacitors

Hardware

S107 - J.W. Miller 2112

10 – 365pF per gang, 2 gangs, 180 degree shaft rotation

This air variable capacitor was used in the audio oscillator stage as well as in the later model AZ-58's to tune the carrier, only one gang was actually used. This is a bit of a waste and one assumed they were just in stock so a single gang capacitor was not procured. This capacitor would not have had a very high breakdown voltage so is not really ideal for tuning the ray tube, but it did work. At the higher voltages mentioned it would certainly have failed due to insulation breakdown. It is a common 10 – 365p air variable available from several manufacturers. I have not been able to locate the specific data sheet. It seems to have had 2 x trimming capacitors 18pF , but this is unclear as external ones were fitted. It is possible to get this type of capacitor without trimmers.

OEP have been in business since the 1920's and still maintain a catalogue and sales of this type of air variable capacitor amongst others. http://www.orenelliottproducts.com/contract.htm

MAXIMUM AND MINIMUM CAPACITANCES, S-2 & S-3 (in pF)

Number of blades	STANDARD BLADES .0125 air gap min.	max.	.017 air gap min.	max.	.0415 air gap min.	max.	OSCILLATOR BLADES .0125 air gap min.	max.	.017 air gap min.	max.	.0415 air gap min.	max.
3	4.9	38.2	4.9	30.3	4.6	14.2	5.5	22.7	6.3	18.0	5.4	11.0
5	6.1	70.7	5.0	54.6	4.8	24.0	6.0	42.0	6.5	32.1	5.6	16.4
7	6.6	103.5	5.2	79.2	5.0	33.8	6.5	60.5	7.0	46.3	5.8	21.9
9	7.1	136.3	5.3	103.4	5.6	46.1	7.0	79.0	7.7	60.1	6.0	27.6
11	7.3	168.8	5.5	126.8	6.6	58.5	7.2	97.2	8.0	73.5	7.0	33.9
13	7.5	201.3	5.7	150.9	7.9	69.7	7.4	115.4	8.7	87.2	8.4	40.0
15	7.8	234.0	6.1	174.5	9.4	80.9	7.7	133.7	9.0	100.6	10.2	46.5
17	8.2	266.7	6.2	199.2	10.4	92.6	8.1	152.1	9.8	114.5	11.4	52.9
19	8.7	299.5	6.7	223.0	—	—	8.6	170.6	10.0	127.8	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	9.2	189.2	10.8	141.7	—	—
23	10.3	365.7	8.4	274.3	—	—	10.2	208.2	11.6	155.6	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	11.4	227.4	12.4	169.4	—	—
27	12.5	432.5	—	—	—	—	12.4	246.4	—	—	—	—
29	13.5	465.8	—	—	—	—	13.4	265.4	—	—	—	—

From the OEP catalogue the air gap is 0.0125" with a maximum voltage rating of 600V!

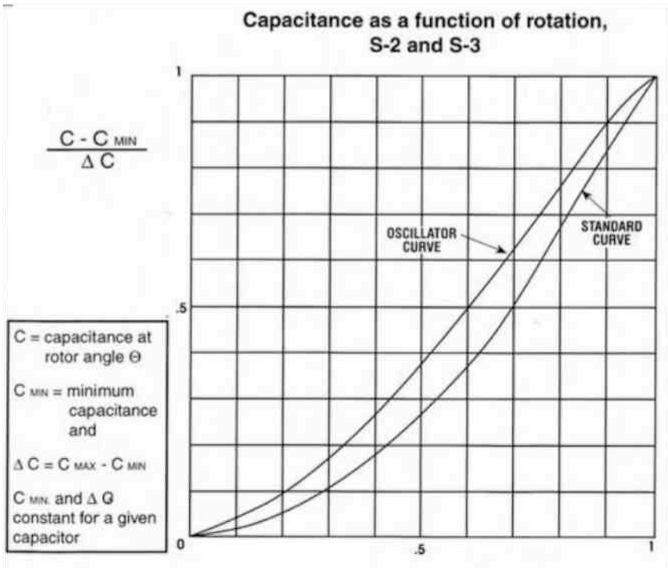
There are safety factors built in to these manufacturer's ratings and it is a wonder the capacitor did not arc over. But it did here is a reference to Major Garff on the issue: http://www.rife.org/letters/580425crane.jpg

The ARRL Handbook suggests the following for safe air gaps.

Air gap			Breakdown Voltage	V/mm
Inches		mm		
1/64	0.015	0.4	1 000	2 625
	0.02	0.5	1 200	2 362
5/16	0.03	0.8	1 500	1 969
	0.05	1.3	2 000	1 575
	0.07	1.8	3 000	1 687
	0.08	2.0	3 500	1 722
1/8	0.125	3.2	4 500	1 417
	0.15	3.8	6 000	1 575
3/16	0.175	4.4	7 000	1 575
1/4	0.25	6.4	9 000	1 417
	0.35	8.9	11 000	1 237
1/2	0.5	12.7	13 000	1 024

Used in the audio oscillator stage this variable capacitor has to be insulated and mounted on a Plexiglas base, well away from any other metal surface. It is best to cut a hole in the base so any capacitive effect between the frame and the chassis is minimised. The ¼" tuning shaft also has to be insulated. There is usually a 6:1 type vernier drive on this shaft for accurate tuning.

This would be a typical ball bearing vernier drive, the AZ-58 used the drive that came as part of the of the National CAN tuning dial.



This type of air variable capacitor had a characteristic STANDARD curve, where a uniform dial movement has a non-linear function to capacitance. This is due to the offset of the plates to the spindle as well as the shape/area of the plates.

Here is a 6th order polynomial function that will convert shaft position 0 to 1 in to a proportional capacitance value 0 to 1. Error is 0.3%

F(x)=0-0.0242609118599311*x+1.71806849021839*x^2-1.5722146478913*x^3 - 0.807084768301254*x^4+ 4.18586128534207*x^5-2.50093416574711*x^6

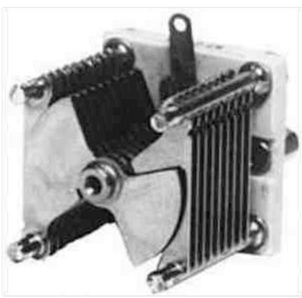
Cmin = 10p, Cmax = 365p, deltaC = 355m dial = 0 - 100

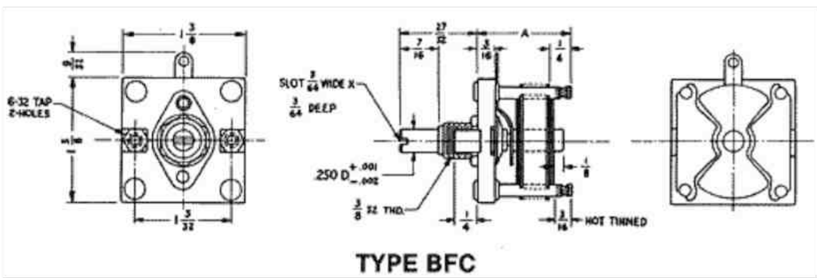
C = deltaC x fx(dial/100) + Cmin

This function can be used to extrapolate dial and range settings in to modulation frequencies.

C102 - BFC-12 Hammerlund 12pF

These two trimmers were located either side of the S107 tuning capacitor gangs, and were used for calibrating the frequency and balancing the gangs if required. Bear in mind each gang possibly had its own 18pF trimmer as well. It is not clear under what circumstances these were used. Possibly to try and get a greater degree of calibration accuracy. This particular trimmer is called a butterfly type, but in its application this symmetrical feature was probably not used.



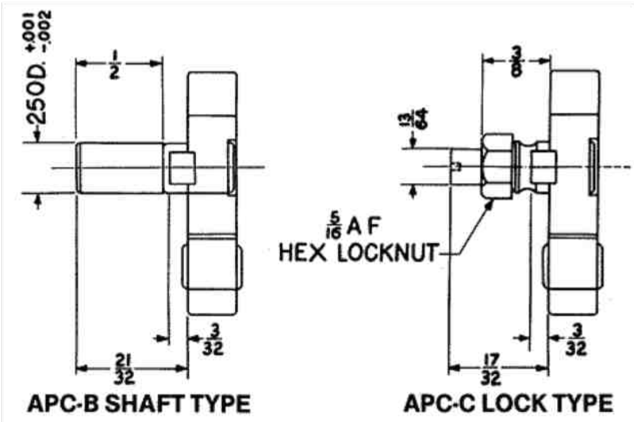


CODE	CAPACITY/SECTION		SERIES CAPACITY		PLATES		DIMENSION
	Max.	Min.	Max.	Min.	Rotor	Ea. Stator	"A"
BFC-12	14.5	3.4	7.6	2.2	4	3	29/32
BFC-25	27.3	4.8	14.1	2.9	7	6	1-13/64
BFC-38	40.1	6.2	20.6	3.6	10	9	1-1/2

The BFC capacitors have a straight line capacitance characteristic through their rotational range of 0 to 90 degrees. The nominal air gap is 0.030". The breakdown test voltage is 1690 volts peak, 60 hertz.

S110 - APC25 – Hammerlund

This trimmer was also used in conjunction with S107 audio generator tuning capacitor. Classically this would have been across the capacitor gang in the series leg, and would have been used to adjust the output levels of a Wien bridge oscillator. As this oscillator has deviated away from that it probably allowed frequency to be set, and had an influence over duty cycle.



CODE	CAPACITY		PLATES	DIMENSION "A"
	Max.	Min.		
APC-15	17.	2.8	5	17/64
APC-25	25.	3.0	7	21/64
APC-50	50.	3.9	14	1/2
APC-75	75.	4.6	20	11/16
APC-100	100.	5.5	27	59/64
APC-140	140.	6.7	37	1-7/32

Note: When ordering the APC-"B" or "C" type, add the suffix -B or -C to the above listed type number.

Both of these capacitors are available from http://cardwellcondenser.com/PAGES/hcBFCseries.html

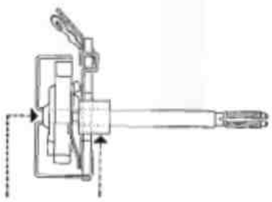
Hardware

C114 - Mallory Midgetrols U29

25k Variable Resistor for setting the modulation level. This was pre-set within the unit. It is a fairly standard carbon track potentiometer.

MALLORY Midgetrols®

do a trouble-free job for you



Two-Point Suspension

Only with Mallory Midgetrols do you get two-point suspension —the feature which gives more stable resistance values and longer control life. It also permits specification of longer shafts and makes it possible to use shorter shaft bushings.

When you use Mallory Midgetrols you take advantage of outstanding carbon control design, construction and performance features that pay off on your production line . . . and in the homes of your customers.

ON THE LINE—Exclusive two-point shaft suspension eliminates side play and makes possible use of heavy pressure to attach knobs without control damage.

Two-point suspension also results in a shorter shaft bushing and thus saves space in chassis arrangement.

Versatility of design permits Mallory to make quick delivery of standard units adapted to meet production emergencies . . . for short runs . . . for experimental work . . . or for service replacement stocks.

IN THE HOME—Two-point suspension eliminates shaft wobble—thus prevents damage to the carbon element.

Resistance drift is sharply limited because the phenolic base of the carbon element resists extremes of temperature and humidity.

Quiet operation and smooth tapers because of the fine molecular structure of the carbon and exclusive methods of application.

Long-lasting performance because of precision design and construction.

You can see that Mallory Midgetrols offer real advantages in production and in use—advantages that build satisfaction for your dealers and their customers because of the trouble-free performance of Mallory Midgetrols. Write or call Mallory today for additional information on the job Mallory Midgetrols can do for you.

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S106 – National CAN Dial 0 - 100

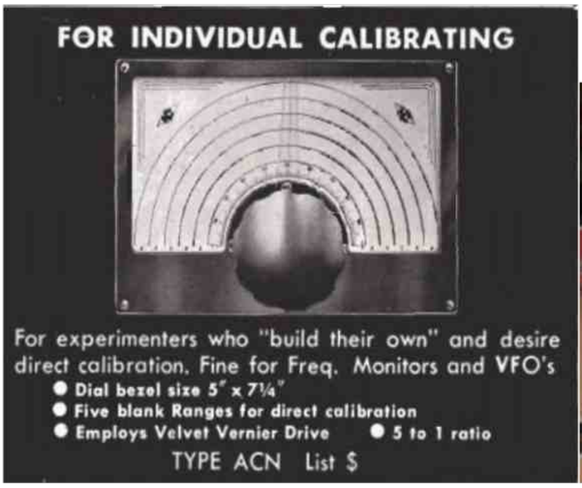


Figure 22 National Radio Products Catalogue 1947

NATIONAL ACN.... "180 degree arc" dials have the Velvet-Vernier drive, a 5:1 tuning ratio (2.5 turns stop-to-stop), and measure 7-1/4" x 5". The scale (5-3/4" diameter) is marked with 100 divisions over 180 degrees and has 5 lines for calibration markings. The ACN front bezel is flat. Velvet-Vernier drives use pinch rollers and are relatively smooth and backlash free, but do require more torque than some other drive mechanisms. At 7.25" this dial face seams a little wide judging from the various pictures. It might have been intended for the new 1958 instrument to give it more tuning accuracy.

S105 – National HRT Knob

Used for the carrier frequency tuning knob.

The HRT is a new plastic tuning knob with a chrome plated appearance circle. The HRT knob fits a ¼" dia. shaft and is 2⅛" in dia. Black or Gray.

HRT Knob List $

The HRS Knobs are a new plastic knob with a 1⅜" dia. chrome plated skirt. HRS Knobs fit ¼" dia. shafts. Three types are available as follows: Black or Gray.

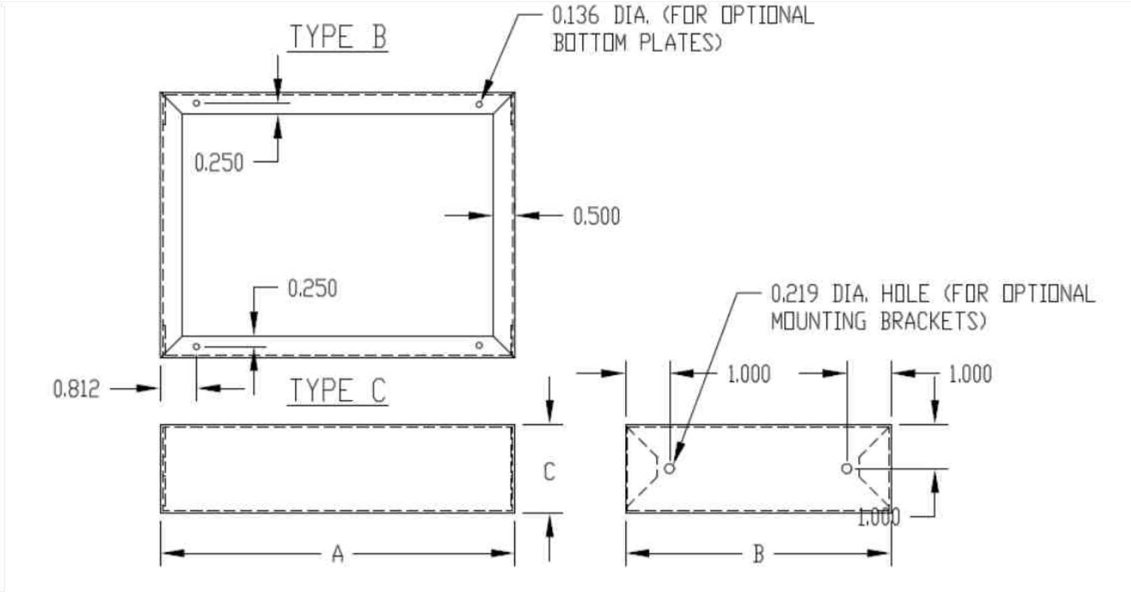
HRS-1 Knob ON-OFF through 30° rotation List $

HRS-2 Knob 5-0-5 through 180° rotation List $

HRS-3 Knob 0-10 through 300° rotation List $

H121 - AC-416 Bud Industries Chassis – Aluminium

- The chassis is still supplied by Bud industries. The chassis is pretty much makes up the width dimension as listed in the specification at 20" (Overall Dimensions 14" high, 13" deep, 20" Long), less the wooden case sides. The spec calls for a 17" wide chassis which is clearly not the case, more likely 19" wide, but when the front panel width is considered the size is more likely 22"

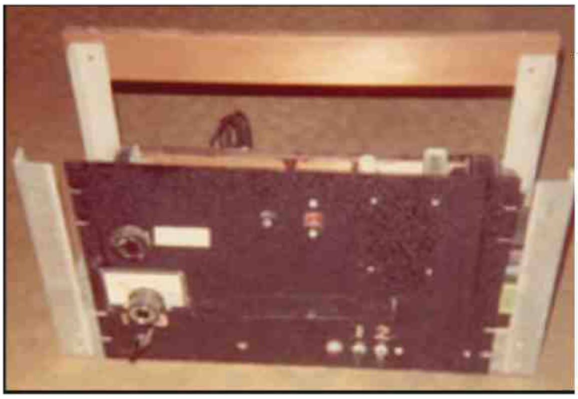


PART No.	A	B	C	TYPE	GAUGE	WT. (#)
AC-401	9.500	5.000	2.500	C	0.040	0.500
AC-402	7.000	5.000	2.000	A	0.040	0.333
AC-403	9.500	5.000	2.000	C	0.040	0.500
AC-404	10.000	5.000	3.000	A	0.040	0.625
AC-405	7.000	7.000	2.000	A	0.040	0.500
AC-406	9.000	7.000	2.000	A	0.040	0.500
AC-407	11.000	7.000	2.000	B	0.040	0.625
AC-408	12.000	7.000	3.000	B	0.040	0.875
AC-409	13.000	7.000	2.000	B	0.040	0.750
AC-411	15.000	7.000	3.000	B	0.050	1.250
AC-412*	17.000	8.000	3.000	B	0.050	1.750
AC-413	12.000	10.000	3.000	B	0.050	1.250
AC-414	14.000	10.000	3.000	B	0.050	1.500
AC-415*	17.000	10.000	2.000	B	0.050	1.500
AC-416*	17.000	10.000	3.000	B	0.050	1.750
AC-418*	17.000	12.000	3.000	B	0.050	2.250

http://www.budind.com/

H123 - Bud Industries PA-1108-B Rack panel 1/8" aluminium

The front panel is stipulated to be 19” wide. This is an old standard still adhered to today for networking equipment. In the photograph the chassis clearly overlaps the front panel by a good 1” – 1.5” which would mean the chassis was actually 22” wide! Notice the panel notch detail is the same as in the photograph.



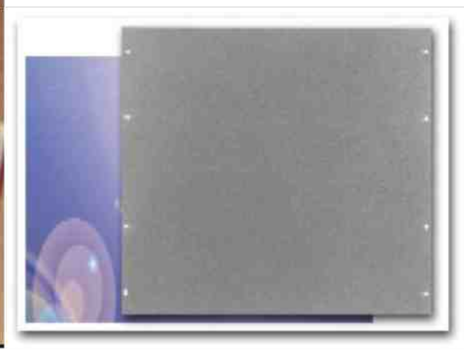
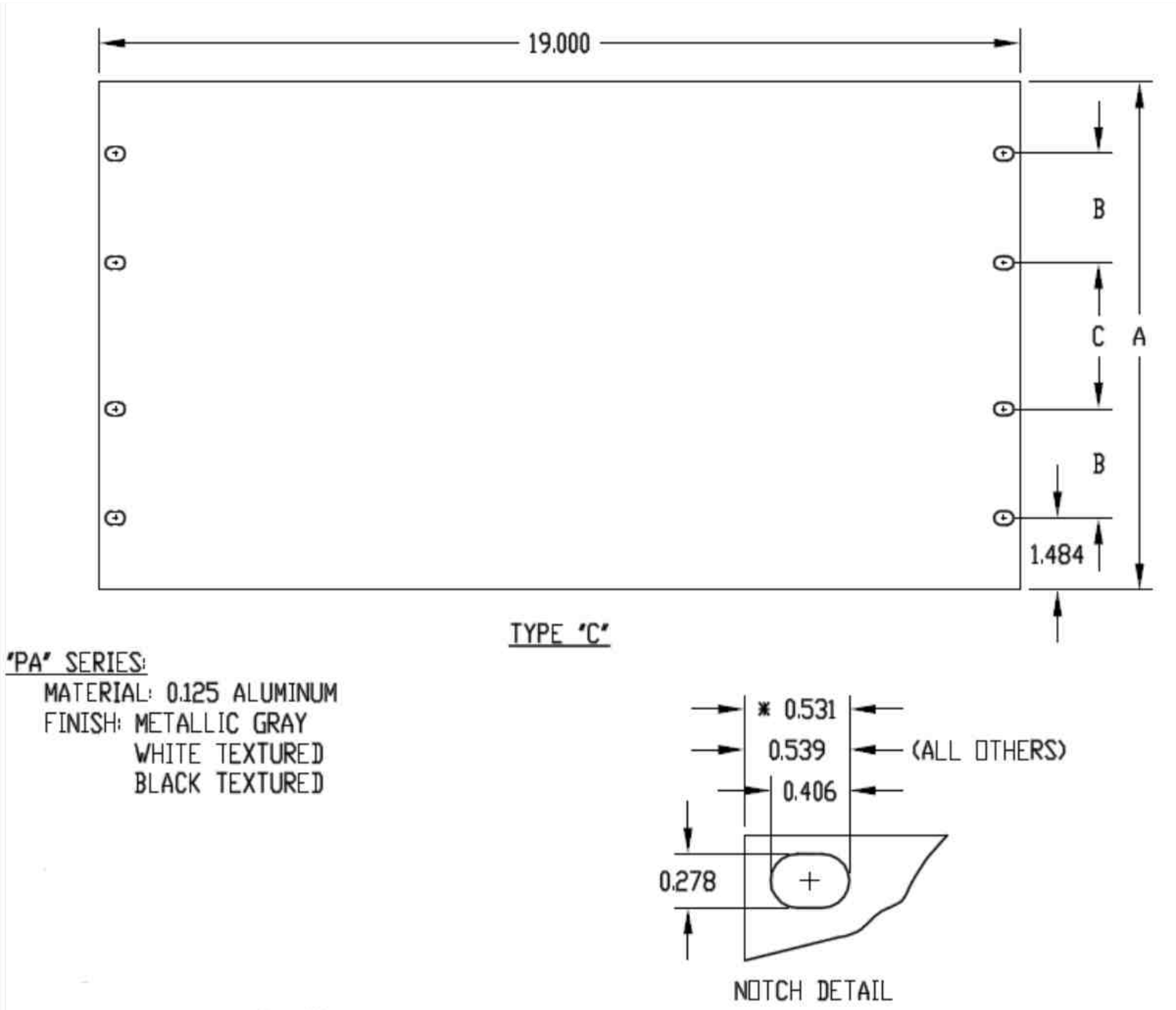


Figure 23 Older face plate, new face plate

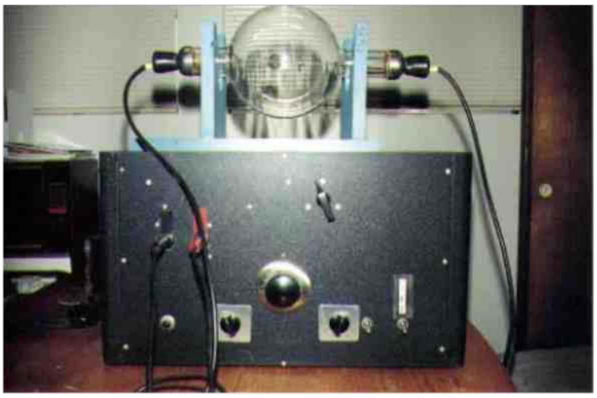


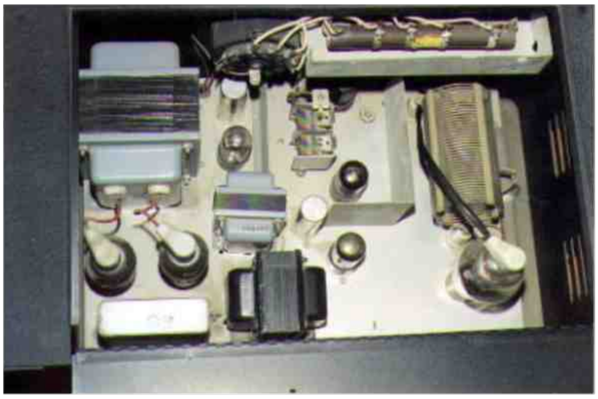
'PA' SERIES	'PS' SERIES	'SFA' SERIES	TYPE	A	B	C
PA-1101	PS-1250	SFA-1831	A	1.750	1.250	–
PA-1102	PS-1251	SFA-1832	A	3.500	3.000	–
PA-1103	PS-1252	SFA-1833	B	5.250	2.250	–
PA-1104	PS-1253	SFA-1834	B	7.000	4.000	–
PA-1105	PS-1254	SFA-1835	B	8.750	5.750	–
PA-1106	PS-1255	SFA-1836	C	10.500	2.250	3.000
PA-1107	PS-1256	SFA-1837	C	12.250	3.500	2.250
PA-1108	PS-1257	SFA-1838	C	14.000	4.000	3.000
PA-1109	PS-1258	SFA-1839	C	15.750	4.000	4.750
PA-1110	PS-1259	SFA-1840	C	17.500	4.000	6.500
PA-1111	PS-1260	SFA-1841	C	19.250	5.250	5.750
PA-1112	PS-1261	SFA-1842	C	21.000	5.250	7.500

H120 Barker & Williamson 3906-1 Air Inductor x 4 1/2" Long

H122 - C-1552 Aluminium Cabinet

When one considers that a Bud Aluminium cabinet was also specified it all fits in to place, Crane was planning a new facelift upgrade the newly named AZ-58 and chose a matching 19" wide cabinet and face plate with a chassis that was smaller width wise to slide in easily. The cabinet could well have looked similar this one that Verne Thompson built. Notice the aluminium chassis is smaller width wise. It has a handy hinged lid to get to the valves. It would have looked more professional than the wooden cases and saved a lot on labour costs.





S108 - Millen 39003 Coupling

Coupled with S109 1/4"dia Stock Plastic rod x 1/2" Lg. will insulate the S107 audio tuning variable capacitor

S111 - 1/4 x 0.87 Plexiglas Stock   Plate x 4" Lg.

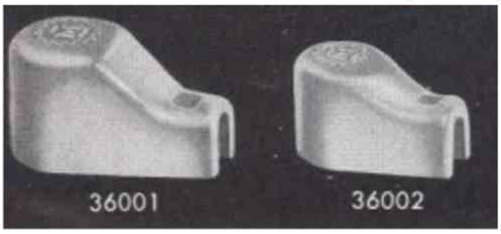
For mounting the C102 and S110 trimmers alongside the variable audio capacitor.

S112 - 1/4 x 3 1/4 Plexiglas Stock Plate x 4" Lg.

To form the insulated base for the air variable capacitor to be mounted on.

H126 - Millen 36002 Ceramic grid cap 3/8" for 812A

H127 - Millen 36001 Ceramic grid cap 9/16" for 816



S104 - Mallory 380 Dial Plate 1 to 5

This plate was marked up 1 to 5 for the audio frequency generator range switch. This then confirms that the AZ-58 in its new form was to have 5 frequency ranges. This is further confirmed by S107 being a 5 position 2 pole switch.

S102 - Centralab 2 Pole 5 Position switch rotary shorting phenolic

This is a make before break type switch. This also confirms the intention to have 5 frequency bands.

This then sets the frequency range from 16 CPS to 6000 CPS over 5 bands. See details under specifications.

S113 - 3 watt G.E. 120 Volt Lamp

This is typical of what the 3x lamps would have looked like. These bulbs are used to stabilise the feedback loop of a Hewlett-Packard type oscillator.

Available from GE Lighting

Incandescent Light Bulb, Lamp Type Appliance and Indicators, Lamp Shape S6, Base Type Candelabra Screw (E12), 3 Watts, Initial Lumens 11, Max. Overall Length 1-7/8 In., Bulb Dia. 3/4 In., Bulb Finish Clear, Average Life 3000 hr., Voltage 120, Lamp Designation 3S6/5.

H120 – Barker & Williamson 3906-1 Air Inductor x 4 1/2" Lg.

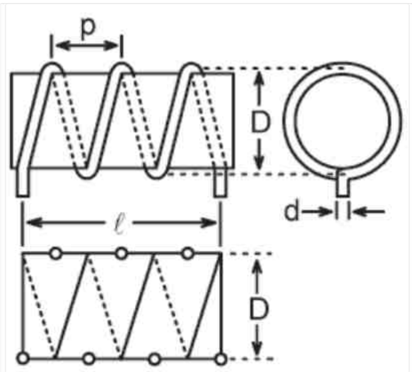
This forms the critical tank coil of the MOPA Hartley Oscillator.

Barker & Williamson (B&W) coil stock is found in vintage amateur gear, especially receivers, transmitters, and amplifiers. They were also found in numerous homebrew amateur radio projects that appeared in QST, CQ, and other amateur publications.

B&W coils have been the industry standard since their introduction in 1932. They made a variety of coils with various diameters, turns spacing, and wire sizes. Minimum power handling capability on most of their coils is 150Watts.

B&W manufactured two types. They made a low power version, for under 150 watts, using flat plastic strips for the coil form. A heavier duty version were made with ribs of polycarbonate round rods intended for high power applications and/or vibration, adding maximum stability. Since the two types had the same diameters, coils lengths, wire size, and inductance, the two can be substituted depending on power level.

B&W Coil Specifications (Note1)						Derived Specifcations (Metric)							
P/N	Inductance (uH)	Coil Length (in)	Coil Dia (in)	Turns per Inch Wire	Wire Size (SWG)	Coil ID (mm)	Wire Size d (mm)	Med Dia D (mm)	OD (mm)	Pitch p (mm)	Gap (mm)	Coil Length	Turns
3009	0.62	3	3/4	4	16	19.05	1.29	20.34	21.63	6.35	5.06	74.91	12
3030 (3906-1)	90	10	2-1/2	8	14	63.50	1.63	65.13	66.76	3.18	1.55	252.37	80
3034	125	10	3	8	14	76.20	1.63	77.83	79.46	3.18	1.55	252.37	80
3030 (3906-1)- Half	45	5	2-1/2	8	14	63.50	1.63	65.13	66.76	3.18	1.55	126.19	40
3034 - Half	62.5	5	3	8	14	76.20	1.63	77.83	79.46	3.18	1.55	126.19	40



B&W also do a handy coil clip that can be useful for making tapings and adjustments.

http://www.bwantennas.com/coils/mini.htm

Corrected Circuit

The following circuit has had all relevant corrections applied; they will be discussed in more detail further on. You could build a functional instrument from the diagram. The usual modernisation would be to replace the 816/866 rectifier tubes with high voltage diodes and us an external frequency source injected in to H107. I have used a front panel switch to switch between internal and external signal sources on my replica. Another useful addition is a plate/grid current meter and a plate voltage meter.

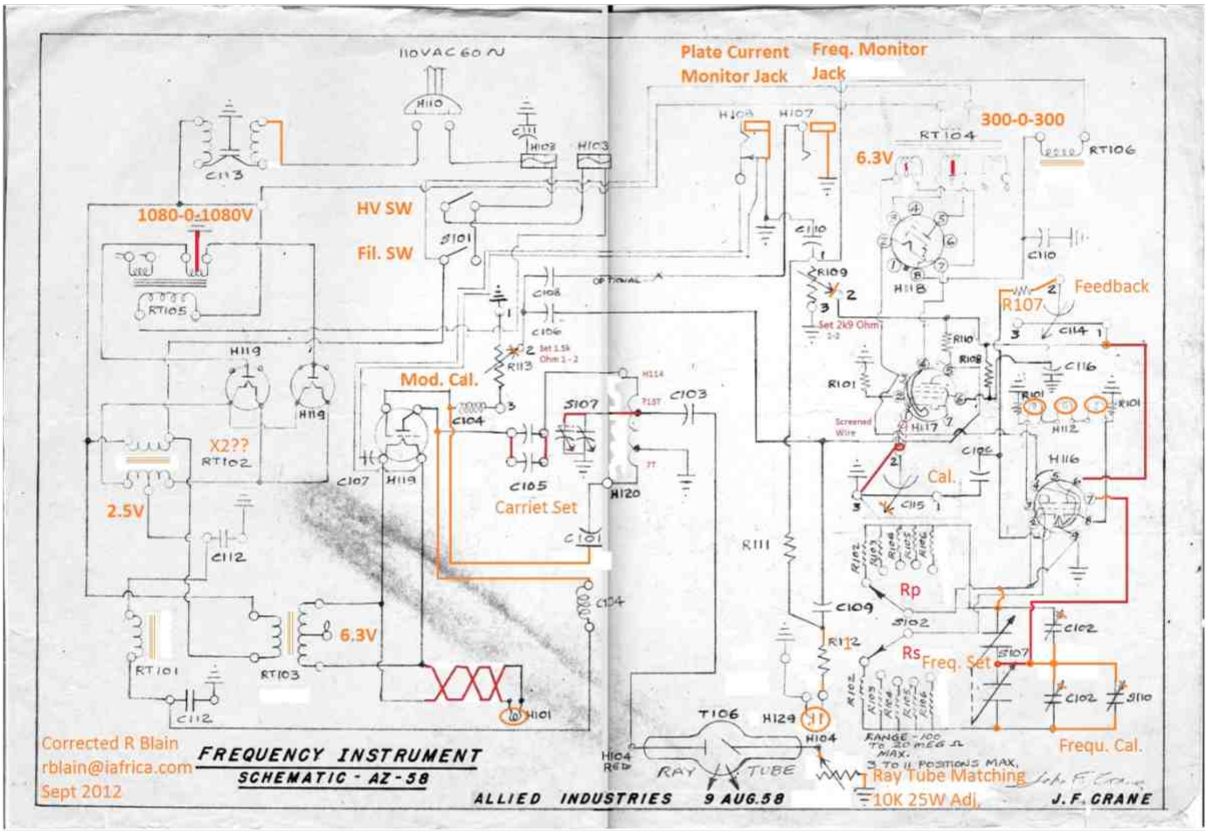


Figure 24 AZ-58 Corrected Schematic Diagram

RED – Parts of the circuit missing from the original schematic but mentioned in the wiring instructions

ORANGE – Corrections applied to make the diagram more readable and correct circuit errors.

The above schematic represents a fully functional tested AZ-58, adhering closely to the original design intentions as possible. There are no modern improvements.

Understanding the AZ-58 Square Wave Frequency Generator

On the original circuit diagram the 1st 12AT7 triode has no anode or grid connections, but from the tube voltage measurements we know something was connected to the anode, and the cathode shows a bias voltage. The wiring instructions add a bit more detail. The circuit also looks suspiciously like a Wien Bridge oscillator with the double ganged air variable capacitor as well as the resistor banks. However there are a whole bunch of wires that are missing.

To help unravel this mystery an audit was done against the parts list to try and find unused components. R109 39K 1W looked like the missing plate resistor. Now we needed a grid bias resistor, a close match is to allocate a 2nd R112 220k (A Option) a more likely option would be to take feedback from the top of C115 the 500k variable resistor (B Option) , then the unused C111 0.1uF fitted the bill for the feedback capacitor (A Option). C105 turned up a duplicate 2nF 1500V which clearly belonged on the Hartley side. C110 was repositioned on R109 to smooth the output of the resistive divider.

In order for an oscillator to oscillate it has to satisfy certain design criteria. The Barkhausen stability criterion is a mathematical condition to determine when a linear electronic circuit will oscillate. It was put forth in 1921 by German physicist Heinrich Georg Barkhausen (1881–1956). It is widely used in the design of electronic oscillators

1. The loop gain is equal to unity in absolute magnitude
2. The phase shift around the loop is zero or an integer multiple of 2π

Now the current circuit at face value would appear to be wrong. An anode connected to B+ is characteristic of a cathode follower stage, but a grounded grid on the other triode? Must surely be a mistake? Then I managed to find this article on cathode followers "The Cathode Follower" by A.P. Blackburn which appeared in the November 1955 issue of The Radio Constructor.
http://diyaudioprojects.com/Technical/Papers/cathode-follower-blackburn.htm

The advent of television in the middle thirties demanded a circuit which would isolate valve amplifying stages from one another, and present a high input impedance to the output of the previous stage, and if possible a low impedance to the next stage. The invention of the cathode follower was the result of this requirement. The cathode follower is a wideband circuit, and usually has a gain of less than one. By using the 2nd triode a measure of gain can be introduced.

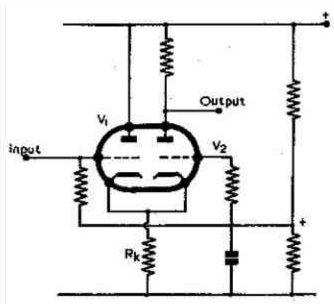


Fig.5

Rk can be represented as the lumped impedance of R101 and the incandescent bulbs. And the V2 grid bias can be reduced to a ground level connection. Then you have the amplifier stage used in this unique Wein bride oscillator.

The circuit was simulated in LTSpice to see if it would work and if we could get anything like a square wave output from the given component values, and it worked

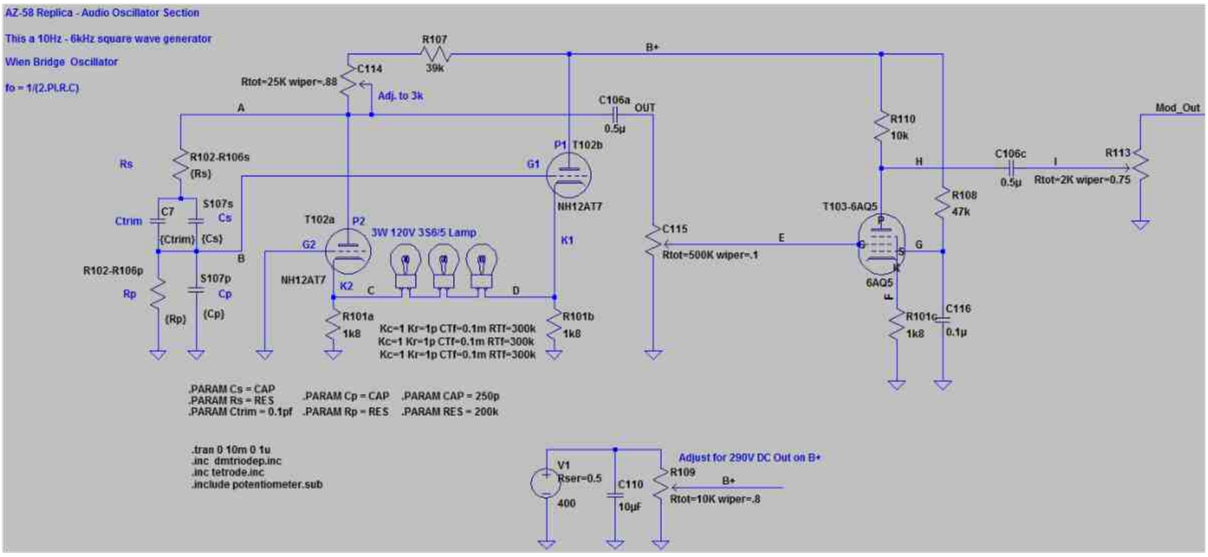
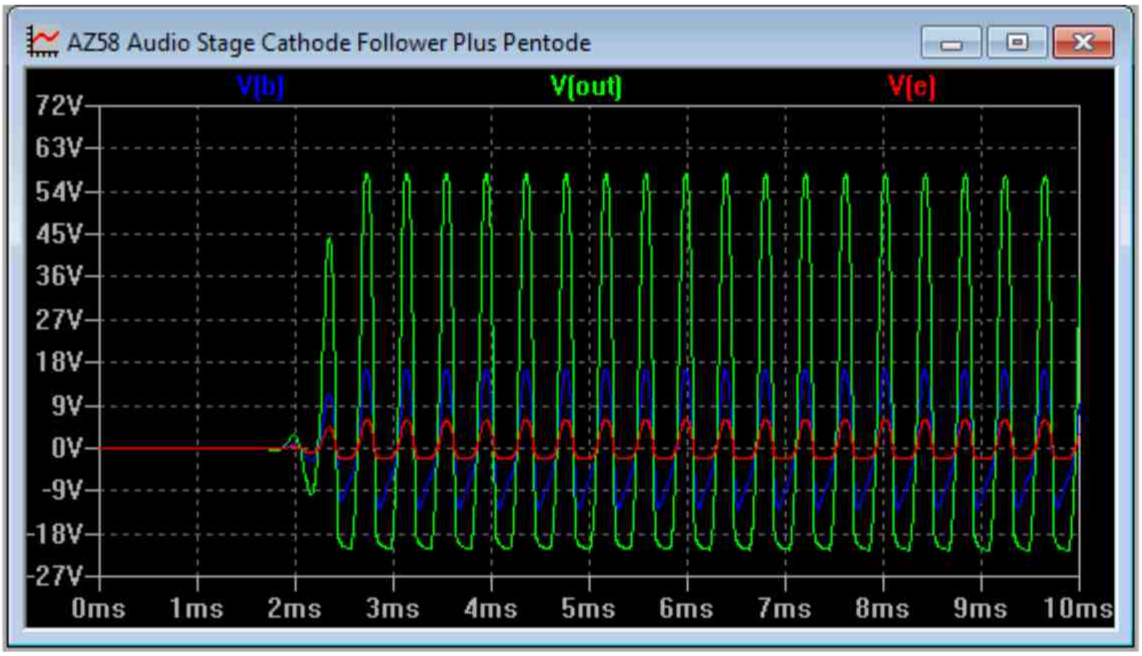
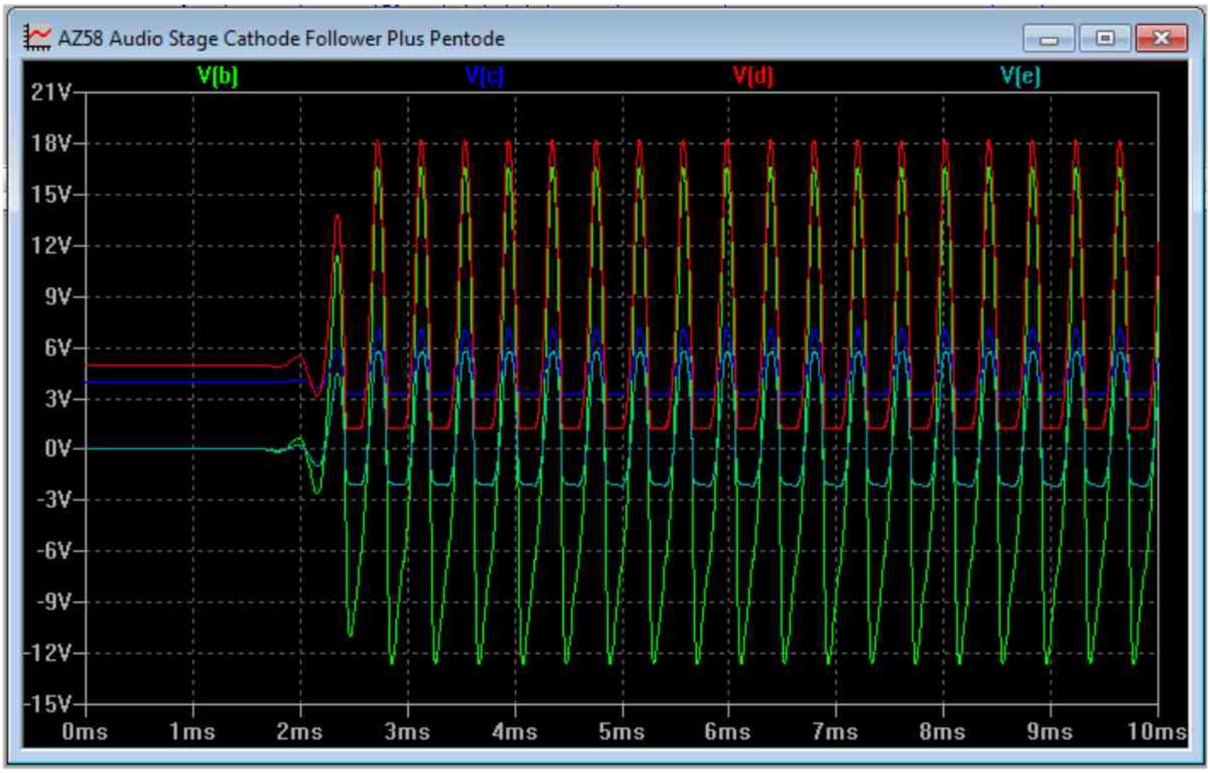


Figure 25 LTSpice simulation circuit of the Audio Stage





Next step was to wire it up in the AZ-58 replica and it to worked!

This is then the original intent of the design, as it involves the absolute least circuit changes and assumptions. A missing earth added to the one gang of S107 and rotor of S107 is connected to grid pin 7 which was omitted from the wiring notes. I did then wire the trimming capacitors in to their classical positions for trimming. The incandescent bulbs do have a negative feedback influence on the first stage stabilising output, however we are running the circuit in to saturation to achieve square waves so the effect is largely lost.

Now this is a very economical oscillator stage, with one dual triode one gets an oscillator and squareish wave outputs however the negative is that the gain of the oscillator is adjusted so high, the triode saturates and the negative feedback stabilisation is not very effective. This will all lead ultimately to instability and sensitivity to component drift due to temperature as well as supply voltage fluctuations etc. It is easy to see why the Eico 377 might have been considered a better option as used in on the Vern Thompson's later designs. It would have used a stabilised oscillator, and then a square wave shaping stage. Seen as this design was possibly conceived in 1953, it would have predated the Eico availability, and sensitised Verne Thompson to finding a better solution for his own instruments, which he clearly did not share with John Crane, except for the Eico 377 becoming one of the first pad devices.

Now the case of the 3 x GE 3W 120V incandescent lamps linking the two cathodes K1 and K2 together. The hallmark of a good oscillator was for it to follow in the footsteps of the Hewlett-Packard design and use an incandescent lamp for amplitude stabilisation. These lamps have very little effect on the operation of this oscillator, in fact they can be removed and it will still operate. The lamps do shift the bias point around a bit, so you do get a slight frequency variation, with and without them. It was either for show, i.e. 3 times better than HP or a crude attempt to get some frequency stability with temperature and voltage changes.

The trimmers C102 and S110 are all linked in series, thus being non effective. I believe the C102 trimmers were used to balance the C107 capacitor tuning gangs, and S110 in its proper position could give some level of overall control. In a classic Wien Bridge S110 in the position I have indicated is used to set the output levels of the oscillator by adjusting the bridge divider ratio which is supposed to be 1/3. In this relaxation mode of operation it is not useful at all except to set the upper limit of frequency range. If the calibration procedure Crane used, ever comes to light then the function of these trimmers will be better understood. On my replica, the trimmers set up my maximum range of 6000 Hz in the top band.

I have searched the available literature for any information on this style of oscillator and no references can be found. Why did they not just use the HP style as was clearly available in the Eico 377 type kits? It would have been far more accurate. Either Verne Thompson wanted to keep the better frequency generator for his own designs, or there was a drive to cut down on components, or were there concerns over royalty and patent issues? The classic HP design would have been well known by this time, however subject to patent protection and royalty, so maybe enough deviation had to be shown so as not to violate the HP patents. From the available letters this oscillator design was a major source of frustration and distrust in the instrument.

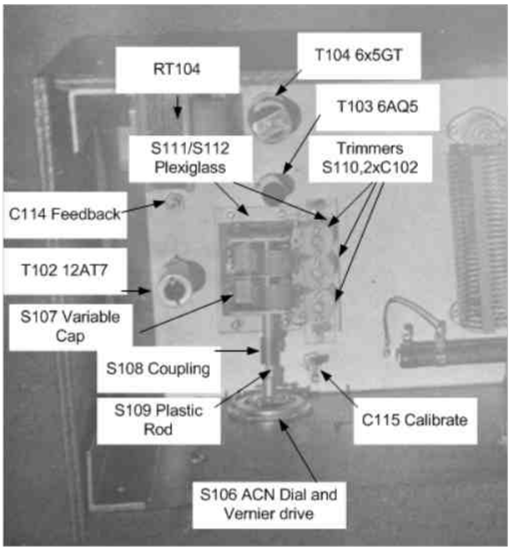


Figure 26 Audio Stage component locations

In order to modulate the MOPA and allow the adjustment of modulation, it is nessasary to have a buffer amplifier stage. From the calibration notes we know the Audio Stage output was attenuated through C115 (A variable resistor R500k) and the output is set to 4Vrms, this sets the input level to the 6AQ5 stage. Now the output is decopled through capacitor C106 and feed in to R112 the 2K adjustable wire wound grid bias resistor. The wiring instructions are very specific that this must be set to 1K5 from ground, and represents the load the 6AQ5 stage will see. Now we have a problem!! There is not enough drive in the 6AQ5 stage to effect much in the way of modulation! The 6AQ5 is rated to drive in to a 10K load. Now this could not possibly have been the case as we know the device worked. The only explination is that the grid bias resistor was in fact a diferent value and the adjustable tap was not set to 1k5, but at a level to at least provide for 100% modulation.

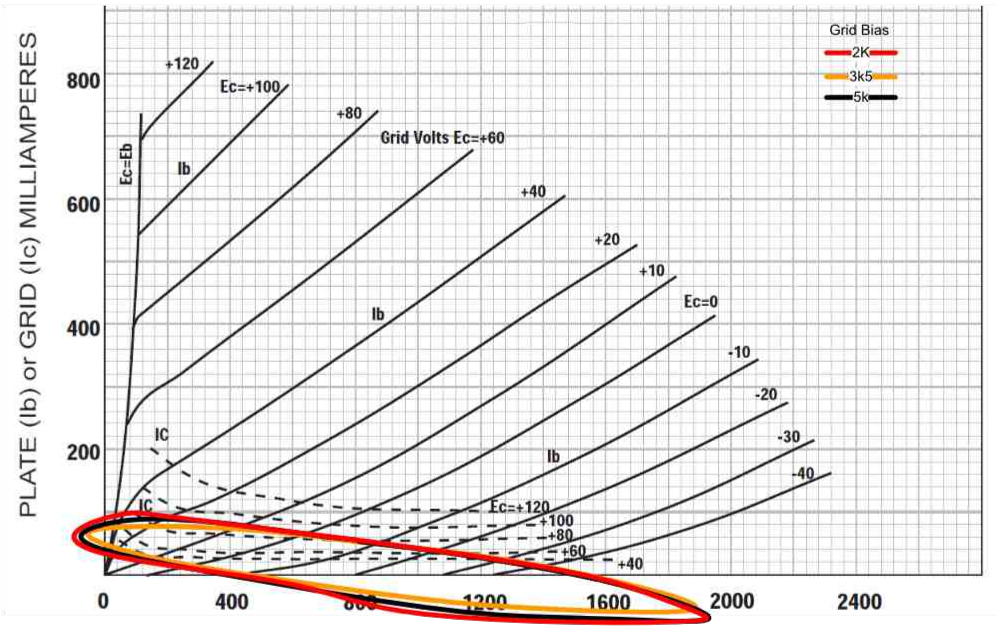
Now grid bias resistors are usually tube manufacturer specified for the different classes of operation, so as never to over-drive the grid. I have compiled a table of typical supplier recommended grid bias resistor values:

```
J) Grid Biasing:
Tube       CCS   ICAS
809 -      4500  3000  Class C Power Amp/Osc
            75W   75W Sometimes Rg=2000
          1000V 1000V
811 -      2500  3200
           117W  170W
          1250V 1500V
812 -      5000  7000  Class C Power Amp/Osc
           116W  170W
          1250V 1500V
812A-      3400  3300 Class C PA + Modulation
            85W  130W  Ig-max = 35mA
          1000V 1250V
```

The 812A should have been set to 3.3K ohms and not 2K Ohms. It is important to note that the value of the grid bias resistor also sets the Class-C operating point for the triode. This is the reason why you can’t just swap tubes and if you do, you should change the grid resistor.

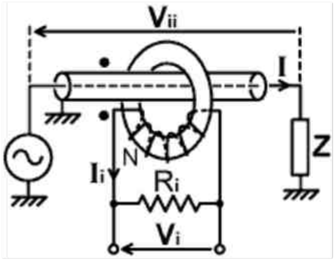
Knowing the grid bias resistor affects the operating point of the tube, I conducted a series of tests using different values of grid resistor, so see what the effect on the operating load line of the triode would be to satisfy myself that changing from 2K to a higher value would not have a material impact on operation of the triode.

812A – Plate Characteristics & AZ-58 Class-C Load Line



The scope was placed in XY mode with plate voltage on the X scale and cathode current on the Y Scale. These load lines were then superimposed on the 812A’s characteristic curves. A load line is usually thought to be linear, and in the audio range that is true, however as we are driving highly inductive loads at resonance, we can expect a phase shift in the circuit, creating these oval load lines. There is not a material difference between the wide ranges I tested, except that the 2K range does produce a more aggressive shape that might produce more harmonics. I am satisfied that we can recommend a grid bias resistor that will allow the 6AQ5 to at least get to 100% modulation of the MOPA.

In order to measure the RF Current a probe was bade consisting of a ferrite core, with a 5 turn secondary terminated in a 50 Ohm resistor. The current carrying conductor is passed through the core and the resulting current read across the resistor. The scale is 100mA = 1V. The current carrying section is made from a small length of COAX and the screen is grounded, with the whole device placed in a metal enclosure for RF screening.



Vi = I * Ri / N

The current probe was calibrated, using a frequency generator and a 50 Ohm load resistor Z with the current probe in series with the circuit. Input voltage was converted to current then compared to the current reading. The secondary turns were adjusted until the error was minimal. Test at a frequency of 3 – 4 MHz. Make sure your ferrite core can handle the HF frequency range.

Output in and out of the 6AQ5 is as follows:

This is with the more or less 4v rms on the grid as specified and gives a full swing of 20Vp-p in to an approximate 1k5 load. The 6AQ5 does not have a cathode bypass resistor, thus introducing negative feedback which eats up the gain. Even a 10uF across R101c will increase the gain. It could be conceivable to swap the 10uF screen grid cap C116 for the spare 0.1uF C111, and install C116 as the cathode bypass capacitor.

Hartley Oscillator MOPA's – OR NOT!

The RF Oscillator stage is a classic Hartley master oscillator stage, that is grid modulated with the square wave audio frequency signal. Depth of modulation is set by R113, as well as C106. The term "Master Oscillator Power Amplifier or MOPA" is incorrectly used to describe this arrangement. A MOPA according to the period literature is a Master Oscillator followed by a Power Amplifier stage. The rationale being that the oscillator is not loaded by the antenna and maintains frequency stability. The period name for this style of oscillator is an Exciter ,Oscillator Transmitter or Single Stage Transmitter. I can't find one reference that supports the term MOPA being applied to a single valve oscillator RF stage. The MOPA terminology started to emerge in the late 40's. I used ARRL Handbooks, RCA notes as well as period radio engineering handbooks to determine this.

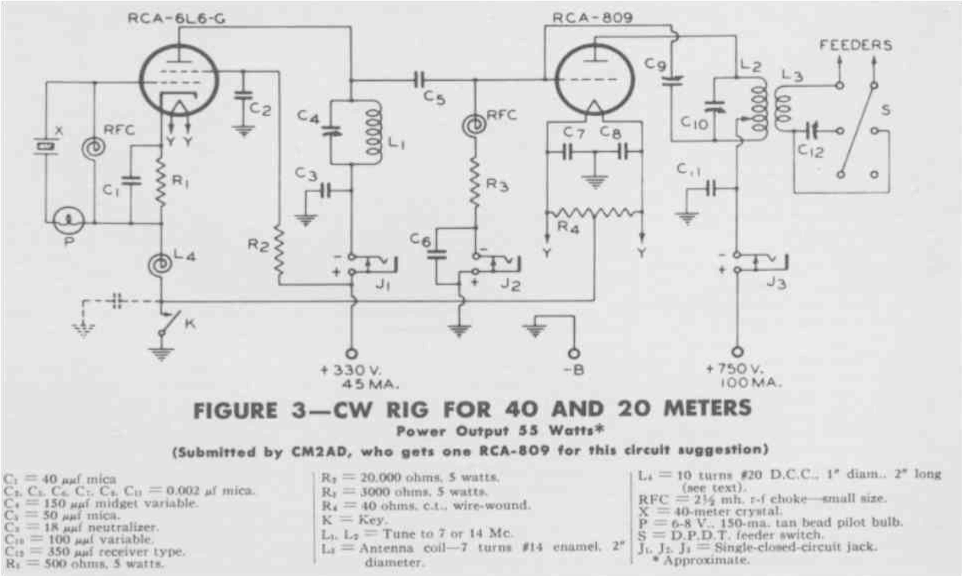


Figure 27 This is a typical MOPA configuration RCA Hamtips 1939, however no called that at that time.

A more definitive reference to what a MOPA is can be found in the "Navy Electricity and Electronics Training Series 1998" here http://www.hnsa.org/doc/neets/mod12.pdf

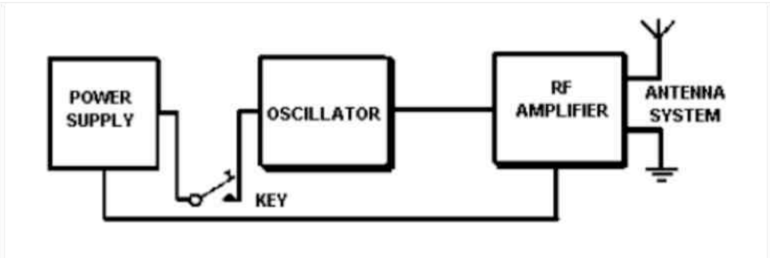
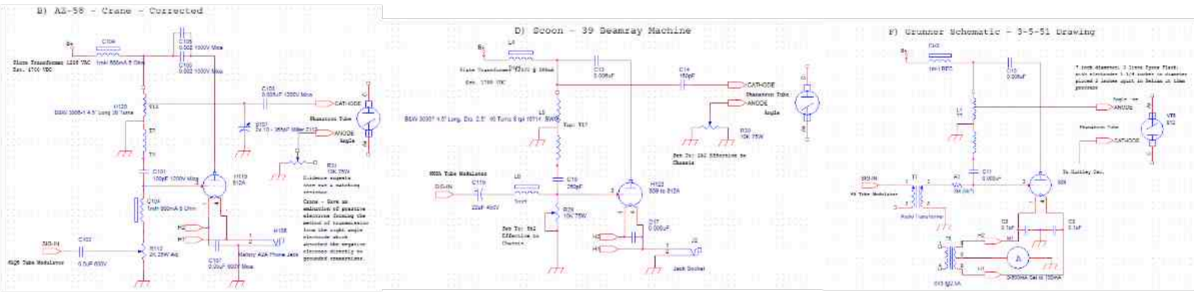


Figure 1-29.—Block diagram of a master oscillator power amplifier transmitter (mopa).

What's wrong with this picture?



Now there are some glaring anomalies when you look at this circuit, and in fact the Scoon Circuit, Grunner Circuit, the Beamrays Device they are:

- There is no provision in the circuitry to try and control the oscillation of the resonant tank circuit. In all the period RF references the Hartley oscillator has an inductor coil and a variable capacitor across the entire tank coil to set the operating frequency.
- This design uses a rough cut coil of 4.5" from B&W coils stock, with no provision to trim the coil's resonant frequency. Some like James Cunningham did suggest tapping the end of the

coil to reduce its inductance, but there is no evidence to suggest there was any tuning whatsoever in this crop of Rife devices. Only John Crane added a way to vary frequency, and his intention was to tune the intensity and radiated power output by better matching to the ray tube, this was a late addition to the AZ-58.

- If RF carrier frequency stability was desired, crystal controlled oscillators were in use in the 30's and would have been a far more natural choice, especially for a fixed carrier
- Instead, the capacitive portion of the resonant tank was purely made up of tank coil inter-winding capacitance, stray capacitance, triode inter-electrode capacitance and the capacitance of the ray tube itself, which could vary depending on its distance and coupling to objects in the environment, not to mention the long length of cables running to the tube, up to 6".
- Notice the orientation of the Plasma Tube differs!
- The Scoon 1939 Device has a rather unconventional way of injecting the modulation signal through an RF choke.

I firmly believe the carrier in these devices was purely a method used to light the tube and nothing more. Being a class C amplifier, and driving a non-linear ray tube, it would have been a rich harmonic generator. This coupled with the modulation would have produced a wide range of harmonic's.

I am not saying the that Jeff Gaarf's harmonic theory is not relevant, as any given instrument will emit a specific set of harmonic frequencies; it is possible that an instrument could have a unique set of dial settings unto itself that would have been effective. This pre-supposes one has a lab and a technique to identify the critical MOR settings and document the dial settings. This is something that Hoyland had access to, and Vern Thompson had some knowledge of.

The Hartley Oscillator

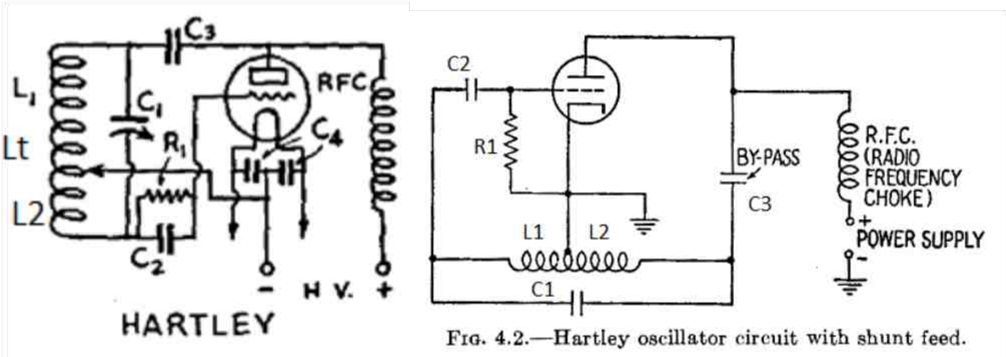


Figure 28 ARRL Handbook 1936, Cruft Electronic Circuits 1947

There are several possible configurations for a Hartley oscillator. This particular example is a parallel (shunt) feed Hartley in that the plate supply voltage and the RF excitation to the tank coil are in parallel. The resonant circuit is primarily made up of the tank circuit L1+L2 and C1 and whatever other parasitic capacitances that are lying around the tank. The output of the amplifier is applied across inductor L1 and the voltage across inductor L2 forms the feedback voltage. The coil L1 is inductively coupled to coil L2, the combination functions as an auto-transformer. Considering the fact that there exists mutual inductance between coils L1 and L2 because the coils are wound on the same core, their net effective inductance is increased by mutual inductance M. So in this case effective inductance is given by the expression

L = L1 + L2 + 2 M and resonant or oscillation frequency is given by the expression

$$f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}.$$

Now the value of C would have to be the following for the following carrier frequencies:

Fo		C	
4.68	MHz	28.6	pF
4.15	MHz	36.3	pF
3.3	MHz	57.4	pF
3.1	MHz	65.1	pF

L = 40.5 uH

C3 is the plate blocking capacitor and is used to provide a low impedance path for the RF currents while preventing the dc plate voltage being short circuited to the filament cathode via the tank centre tap. C2 is the grid capacitor, similarly insulates the grid from the filament and permits the grid bias voltage to be developed across the grid leak resistor R1. C4 is to provide a low impedance grounding path for RF currents. The RFC (RF choke) permits the DC plate currents to flow but blocks RF currents. The L1 tapping point can be used to vary the excitation of the oscillator, by tapping more RF energy to drive the grid of the triode. Before oscillations start there is no voltage applied to the grid, and hence no grid current. The bias is zero, so the plate current exists and oscillations start. When oscillations start, the RF voltage is applied to the grid, causing the grid to draw current. The average value of this current times the value of the grid resistor gives the value of the grid-bias voltage. The grid resistor has a very beneficial effect on controlling the intensity of the oscillations. If the intensity is greater, the RF voltage applied to the grid is greater and the grid current is greater. The grid bias is increased causing the plate current to decrease which in turn cuts down the intensity of the oscillation. If the intensity decreases the grid bias to will decrease, increasing the intensity of oscillation. The use of the grid leak resistor imparts stability to the intensity of oscillation. Injecting the modulation voltage in to the grid bias circuit has the same effect as the intensity of the carrier is now in direct proportion to the level of amplitude modulation applied.

The Triode is configured as a Class-C RF Amplifier. This is a very efficient form of amplifier in which the current flows for less than 180 Degrees typically between 120 – 150 degrees. Efficiency levels are over 65% (812A). Read this as 65% of the energy is output to the circuit and 35% is dissipated in heat internally to the triode! Note: Working out power by multiplying the plate current and voltage only indicates total power in the oscillator, only a maximum of 65% will be available to the circuit and only a portion will reach the plasma tube as output power, depending on SWR and tube matching. Class-C grid bias levels are 2 to 3x the triode cut off grid voltage. At a plate voltage of 1000V this bias level is approximately -50v to -75v.

Maybe we must assume that Hoyland had success with Beamrays as the machines had their dial settings individually mapped to MOR’s. Rifes earlier devices specifically emitted MOR frequencies. The AZ-58 and I would assume the other Verne Thompson replicas would have been a bit hit and miss, until Dr Stafford started to tame the carrier, and inject some semblance of order in to the process.

The original circuit has some pretty awful errors in it, which are easily corrected as this circuit is a classic and the errors were merely due to the ceramic feed-through's being incorrectly traced between the top and the bottom of the chassis..

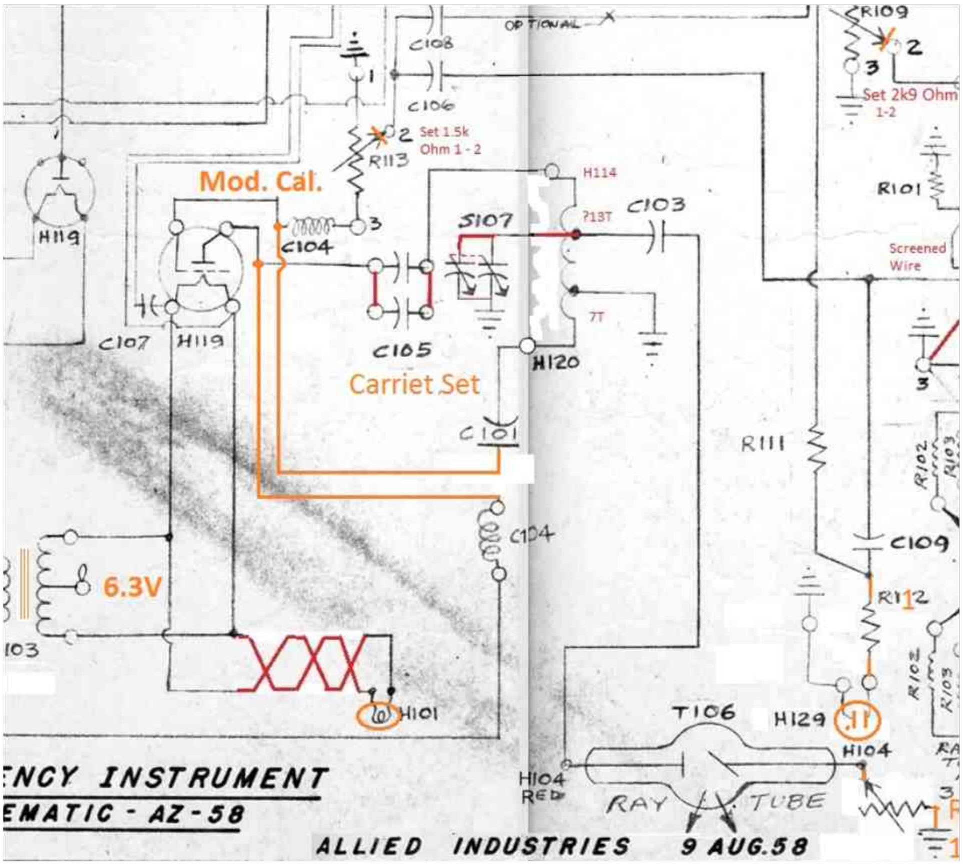
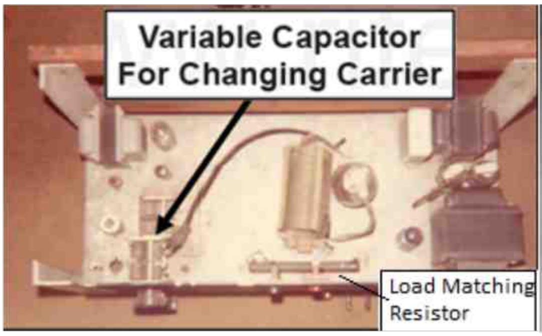


Figure 29 Corrected



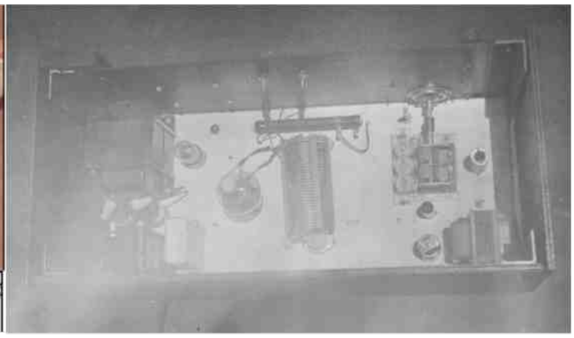


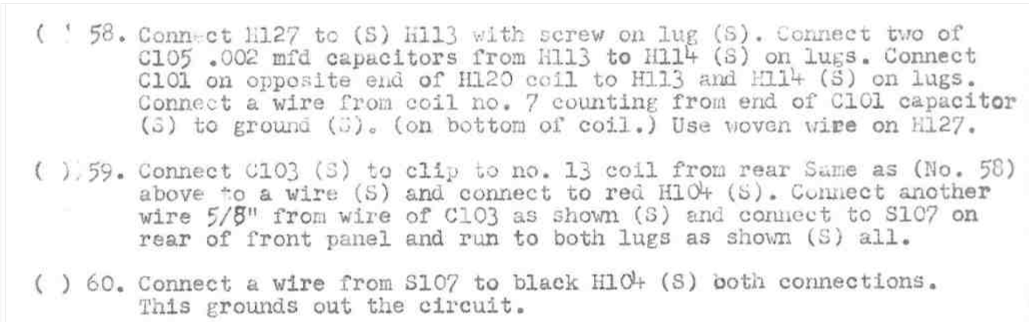
Figure 30 1957 Tuning cap plus load resistor

Figure 31 Early no tuning cap but load matching resistor

The initial AZ-58's would not have had S107 the tuning capacitor added by John Crane / Marsh in order to adjust the intensity of the tube. Clearly visible from all the photographs is a wire wound resistor in the earth lead of the ray tube. This resistor being wire wound is inductive, and is used to offset the capacitive reactance of the ray tube, thus matching it to the MOPA for maximum power transfer. This seemed to be a hallmark of Vern Thompson, a radio man who would have known about these things. It was dropped in the AZ-58 schematic; however John Marsh used matching on his later device. It is not mentioned in the parts list, so I assume John Crane omitted it as he thought he had solved the matching problem with S107. In reality he just made the matching possibly worse, but shifted the resonance point around for maximum power intensity. We have discussed elsewhere about the inadequacy of the breakdown voltage on the S107 variable capacitor and there are reports of it arcing over in practice. I have used a 10K variable rheostat for matching and while monitoring current and voltage phase can adjust matters for maximum power output. There is a marked change in the plasma as you go from zero to the point of match, thereafter it pretty much looks the same. Another interesting anomaly is if you pull off the ground lead and leave it floating the tube lights up perfectly and bright!

Tank Coil Tappings

There is a variation in the way the tank coils were configured based on the photographic and other evidence we have. Even in the AZ-58 range there is a variance. The Wiring instructions are not completely clear on where the counting for the 13T tap to the plasma tube starts, leaving a few possibilities. We aim to discover by examining the records and by experimentation where the tapping might have been.

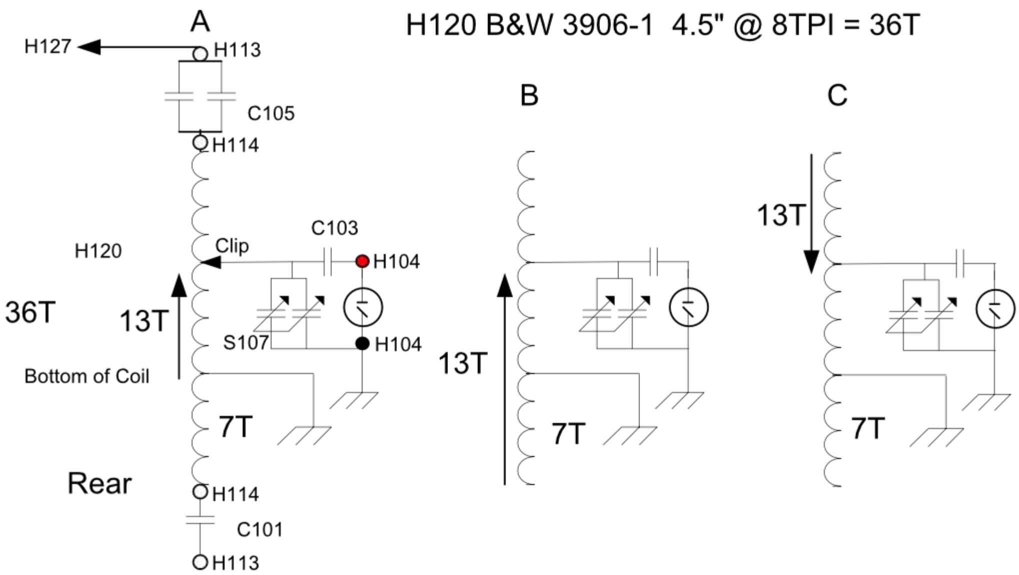


( ) 58. Connect H127 to (S) H113 with screw on lug (S). Connect two of C105 .002 mfd capacitors from H113 to H114 (S) on lugs. Connect C101 on opposite end of H120 coil to H113 and H114 (S) on lugs. Connect a wire from coil no. 7 counting from end of C101 capacitor (S) to ground (S). (on bottom of coil.) Use woven wire on H127.

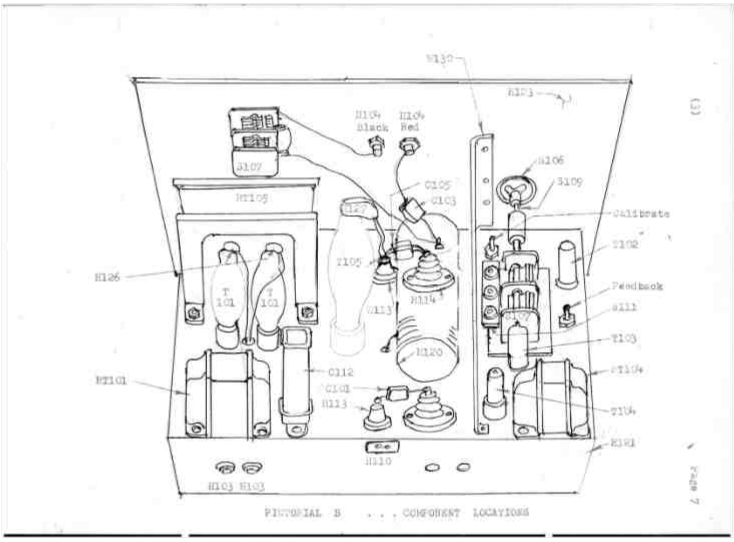
( ) 59. Connect C103 (S) to clip to no. 13 coil from rear Same as (No. 58) above to a wire (S) and connect to red H104 (S). Connect another wire 5/8" from wire of C103 as shown (S) and connect to S107 on rear of front panel and run to both lugs as shown (S) all.

( ) 60. Connect a wire from S107 to black H104 (S) both connections. This grounds out the circuit.

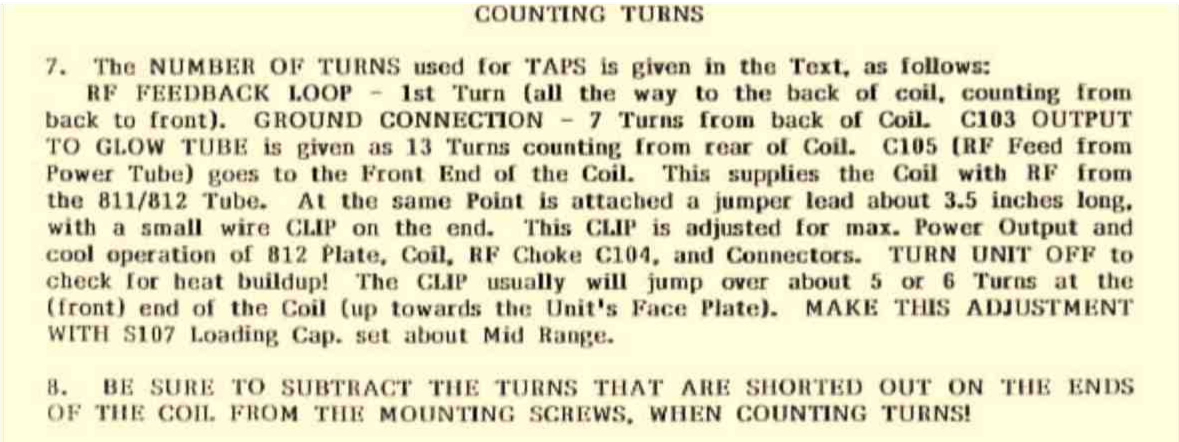
Figure 32 Extract from AZ-58 Wiring Notes



Here are the three possible tapping scenario's A,B and C, based on the notes wiring instructions. I have included component numbering in the A scenario as an aid to interpreting the wiring notes.



The Cunningham construction notes talk about tapping the back of the tank coil to maximise power output, and this evidently were instructions from the original wiring diagram. This was a rough way of adjusting the resonant frequency of the tank coil. Referring to the photographic evidence you can see the relative tapping positions used.

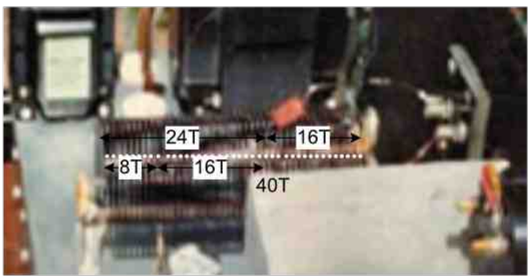


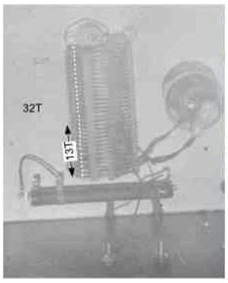
COUNTING TURNS

7. The NUMBER OF TURNS used for TAPS is given in the Text, as follows: RF FEEDBACK LOOP – 1st Turn (all the way to the back of coil, counting from back to front). GROUND CONNECTION – 7 Turns from back of Coil. C103 OUTPUT TO GLOW TUBE is given as 13 Turns counting from rear of Coil. C105 (RF Feed from Power Tube) goes to the Front End of the Coil. This supplies the Coil with RF from the 811/812 Tube. At the same Point is attached a jumper lead about 3.5 inches long, with a small wire CLIP on the end. This CLIP is adjusted for max. Power Output and cool operation of 812 Plate, Coil, RF Choke C104, and Connectors. TURN UNIT OFF to check for heat buildup! The CLIP usually will jump over about 5 or 6 Turns at the (front) end of the Coil (up towards the Unit's Face Plate). MAKE THIS ADJUSTMENT WITH S107 Loading Cap. set about Mid Range.

8. BE SURE TO SUBTRACT THE TURNS THAT ARE SHORTED OUT ON THE ENDS OF THE COIL FROM THE MOUNTING SCREWS, WHEN COUNTING TURNS!

Figure 33 James Cunningham tank coil tapping instructions - He added his own interpretation.





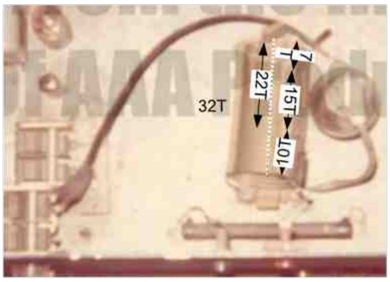


Figure 34 First AZ-58 **Figure 35 Later AZ-58** **Figure 36 Dr Stafford**

The only option right now is to test the A,B and C tapping scenario's and see what gets us closest to the published carriers of the AZ-58. 4.15Mc was mentioned as being the earlier carrier frequency by Dr Rife and Thompson ion their patent, and 4.69Mc was the 1958 frequency when the variable capacitor was added to the tank in order to be FCC compliant. Dr Staffords using the same device was able to adjust his device for maximum radiated power around 3.1 – 3.3 Mc. (Adjustable 2.4 – 4.68 Mc)

The indicator circuit around the neon lamp H129 has been corrected. It serves a dual purpose, one is to indicate the audio stage has power, and the other is an indication of the modulating square waveform frequency. On the lower ranges it gives off a marked flicker which is always comforting.

R113 the 812A grid bias resistor serves a very special dual function. Tube manufacturers will specify the correct value of grid bias resistor for a class C amplifier, under amateur or broadcast operation. This is to do with setting the bias point and load line of the triode to the correct point on the characteristic curves. By knowing the value of this resistor one can fairly easily determine what type of triode was fitted, and is a BIG reason while when swapping between 809,812,812A this value must be changed, or the tube could draw to much current in operation and possibly operate in a non-linear region producing unwanted harmonics and parasitic's. Grids have a maximum power dissipation which should not be abused for long tube life.

Another point to note is the way the 812A's heater is handled. The filament transformer centre tap is not used and the heater is grounded at pin 4 via the plate current test jack. The other side of the heater 1 id RF decoupled with a small capacitor. This arrangement is contrary to ANY good practice available at the time. The 812A's filament doubles also as the cathode. With this arrangement the filament voltage of 6.3V AC is present across the heater, but the one end is grounded and the other end is fluctuation at 50/60 Hz with an rms voltage of 6.3VAC. There is an uneven and fluctuating voltage distribution across the cathode. This in turn modulates the grid cathode voltage, and ultimately is present in the carrier. Id the carrier is over modulated the effect goes away. This is an important point to consider that all Vern Thompson and the Hoyland replica we have all chose to go against standard design practice of the day and introduce this small mains frequency modulation. Standard design practice seeks to minimise or eliminate this mains hum, by grounding at the centre point of the filament transformer, and or using RF chokes in the heater leads. In some audio designs the centre balance point is adjustable. I have examined all the replica MOPA's and they all apply the proper design principles and correct this. To my mind the mains frequency was intestinally introduced in to the carrier, and the concept was carried through all subsequent designs. There was absolutely no cost overhead top correct this so it must have been intentional. Vern Thompson would have felt the urge to correct this anomaly but did not for some good reason.

Carrier frequency uncontrolled

Power Supply

Let us briefly examine the plate power supply and see what the likely DC plate voltage would have been. The Merrit P3158 Plate transformer supported two high voltage secondary's namely 1080-0-1080 @125mA and 500-0-500 @ 150mA, the Merrit estimated plate DC is 1000VDC and 400VDC respectively.

Let's do a rough calculation to cross check these findings with the actual components used:

Vaverage = Vrms x 0.9

Vplate = Vaverage – Vrect – Vchoke

Vrect – rectifier tube voltage drop – Moving to diodes will reduce this value significantly giving a higher plate voltage.

Vchoke – the voltage drop due to resistance losses in the choke itself – V = RxI

- RT101 - Merit C-3181 Filter Smoothing Choke 10H 200mA 140 Ohm
- Mercury Vapour rectifier RCA 816 Tube Voltage Drop 15V Max.

Using the rated current of 125mA:

Vplate@125mA = 1080 *0.9 = 972VDC – 15V – 140 * 0.125 = 939.5VDC

Using a more realistic plate current of 60mA:

Vplate@60mA = 1080 *0.9 = 972VDC – 15V – 140 * 0.060 = 948.6VDC

The plate power supply circuit is absolutely standard and in accordance with design practice of the day. The overrated rectifier filament transformers as well as choke, suggest the power supply might have had its origins in a higher voltage design delivering 2,700VDC, that would have required a 3000-0-3000 Plate transformer!

Circuit Simulation – The Virtual AZ-58

In order to easily simulate the various functions of the Audio and RF stages of the AZ-58 some LTSpice simulations were put together.

Building a Replica

Calibration

Spectral Output

Conclusion

To my mind John Crane was a practical mechanical man, when he looked at electronic equipment all he could see were wires. He understood larger level functional blocks and some of the obvious components. Vern Thompson being a radio man would have known the proper form of schematic documentation and taking proper readings. Clearly he must have had his own private notes, and never revealed this to John Crane. Was this because he had designs on a closer partnership with Dr Rife given their 1955 patent application? or did he somehow feel these were his and Dr Rife's ideas which pre-dated the association with John Crane. John Marsh on the other hand was able to subsequently build two improved versions of the frequency instrument. To do so would have required expert level knowledge of the subject, why did he not assist John Crane to get the schematics right? Given that they were closing in on a manufacturing relationship for Dr Stafford it is possible that a documentation pack was drawn up for manufacturing discussion, but modified so as not to make any practical sense. I think this could have been true to a point; however some of the other errors are too embarrassing for anyone in the know. Some have advocated that these drawings were draft, then why would john Crane sign them and use them in his 1973 patent application; I suggest that to his mind there was nothing wrong with them! It is a great pity that the electronic men associated with Dr Rife (Lee De Forrest, Philip Hoyland, Verne Thompson..) kept all the actual circuits to themselves, leaving the likes of John Crane to fend for himself to build up a schematic by manually tracing out the wiring.

In writing this report, it is clear that a lot of the technical history can be attributed to Verne Thompson, who must have been intimately aware all the circuit details, as well as being privy to Rife's frequency list.

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