

KENWOOD TL-922 (TL-922A, TL922) MODIFICATIONS

UPDATE With a feedback resistor.



LINEAR AMPLIFIER INCL. WARC BANDS

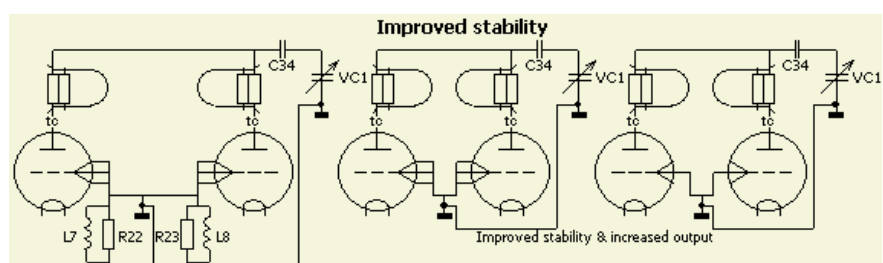
Freq.	1.850	3.650	7.100	10.10	14.20	18.10	21.20	24.85	24.85	28.5	MHz
Po	1150	1300	1300	1000	1300	1100	1150	1100	1050	1100	W
SWR	1.2	1.2	1.0	1.3	1.0	1.2	1.0	1.7	1.1	1.0	
	Band switch on 20m					Band switch on 15m			Band switch on 10m		

9 Bands with 1000-1300 Watt output!



INTRODUCTION

A Kenwood TL922 linear amplifier with 2 × 3-500Z valves is one of the best, sturdiest and compact pieces of equipment for radio amateurs. It is equipped with double shielding in a cabinet of thick material with sturdy handles.

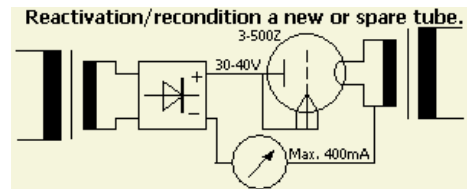


It is designed with good quality components and there are separate transformers for high voltage and filaments. If the HV transformer overheats, a thermal safety device incorporated inside it will operate and disconnects the bias. When you switch off the amplifier, the cooling fan will carry on for a few more minutes. Here are features, which are not present in a lot of current models. This is good advice if you come across a 2nd hand one, however there is always room for improvement.

The filaments have the correct heater voltage if the (NL) 228 Volts mains voltage is supplied on the 240 volts connection of the transformers. With a 100 W exciter the amplifier will deliver about 1000 to 1150 watts on 10, 12, 15, 17, 20, 40, 80 and 160 meters into a 50 Ohm termination. One can also transmit quite a bit of power on the 30 m band with a tuner between the exciter and the amplifier. When all grids were directly grounded, the power increased to 1300 watts maximum.

REACTIVATON 3-500Z

To avoid flashover in a new or a long time unused tube, it is prudent to prepare ("reactivate") it for his task. There are various opinions and solutions how to do it, but with a 3-500Z it can be relatively simple. A DC of 30 to 40 V is sufficient for the tube to draw 400 mA as the grid is connected to the anode. Heat the tube 30 minutes with a filament voltage of 4.9 V. Then supply a "high voltage" of about 35 V and set the voltage to a current of 400 mA. If possible use a current limiter, because during reactivate the current can increase suddenly so that continue monitoring could be necessary to maintain 400 mA. Usually I will not reactivate longer than an hour or so. Soon you will find out at which voltage a good tube drawn 400 mA, so you have an indication if another tube is better or not.

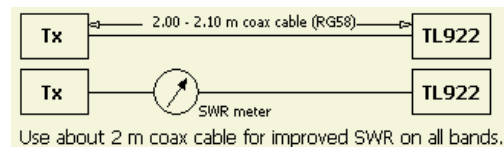


OUTPUT, LOAD & PLATE SETTING ON 9 BANDS AFTER MODIFICATIONS

The 228 VAC line voltage was supplied with the transformers set in the 240V position.
Test array was: Bird dymmy load, wattmeter and 2500H slug; Daiwa CN-101L SWR meter; 2 × 3-500ZG.

Band (m)	160	80	40	30	20	17	15	12	12	10
Pi (W)	100	100	100	100	100	100	100	95	95	85
Po (W)	1200	1300	1300	1000	1300	1100	1150	1100	1050	1100
SWR	1.3	1.2	1.0	1.3	1.0	1.2	1.0	1.7	1.1	1.0
Freq. (MHz)	1.850	3.650	7.100	10.10	14.20	18.10	21.20	24.85	24.85	28.50
Plate setting	7	3.5-7	7	3.5	14	7-1	21		21	28
Load setting	3.5	2.4	3	1	4.5	3.8	4.8		5	5-f

Band switch (BS) on 20m ⚡ BS on 15m ⚡ BS on 10m



Use about 2 m coax cable for improved SWR on all bands.

Maximum performance with about 2 m coax cable.

A stable TL-922 was the result after implementing modifications, like the length of the coax cable between exciter and amplifier, all grids direct to ground (no capacitors) and an extra earth wire to VC1. Sometimes during the daytime the mains voltage is a bit higher and the amplifier can give approx. 50 watts more output.

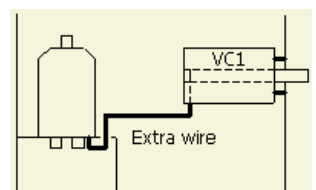
Wire to VC1.

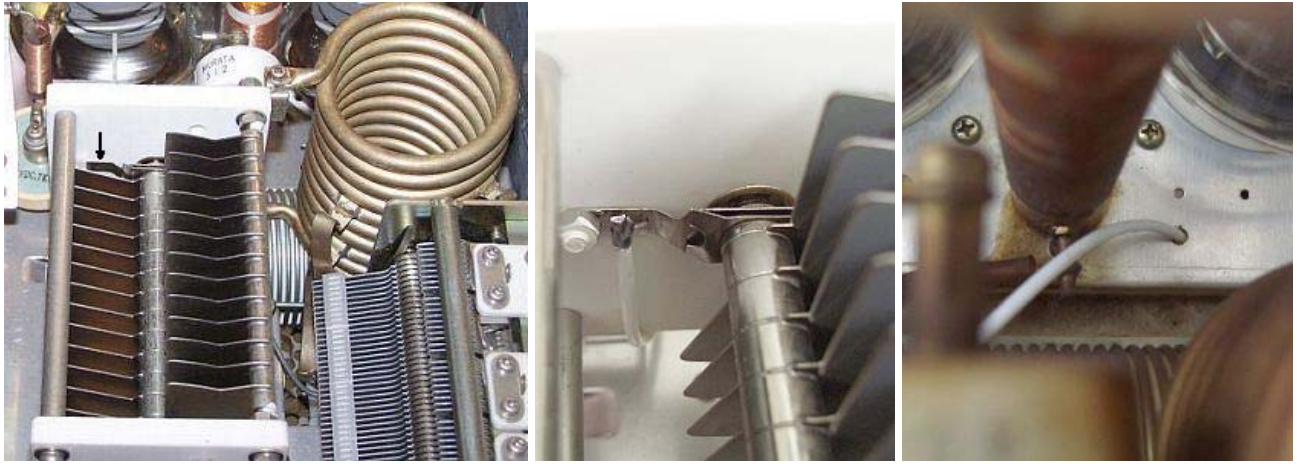
This modification improves the stability by means of a shorter connection to a common RF ground near the valve sockets. Such a direct connection I have done in all HF amplifiers, for example Yaesu FL2100, Dentron GLA1000, AEA LA30, NEC CQ301, Heathkit SB200, TenTec Centaur and my own designs. This was the cause of oscillations on VHF in a lot of amplifiers.

Richard Measures AG6K fixed this problem with multiple parasitic suppressers, but it is far easier and cheaper to have a direct connection from the plate capacitor to the grid connections on the valve sockets. The ground connection of the variable capacitor is in reality "isolated" from the valve sockets, because it is situated in a kind of Faraday cage.

A RF current from the variable capacitor doesn't arrive at the valve socket via the shortest route. It is possible that with other amplifiers too, this will lead to instability.

A direct connection from the variable capacitor to the bottom of the valves will prevent this. You can use an insulated wire through a hole already present in the frame. In my own equipment a feedthrough with solder connections was implemented.

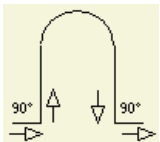




This is the way it was implemented in an amplifier belonging to a fellow ham.

At the bottom you connect the two ground supports, one on each side of the valve sockets, with a length of 2.5 mm² tinned copper wire. This will become the common earth for both valves and the connection for the extra wire to VC1

PARASITIC SUPPRESSION CIRCUITS



A method of parasitic suppression is the insertion of RF current (hairpin shaped) obstacles (dampers) at right angles (\ll fig) to the probable flow of the parasitic currents. This method can be used up to frequencies of several 100 MHz without noticeably reducing fundamental power. The main function is to provide a high impedance path in series with other (tank) circuit elements.

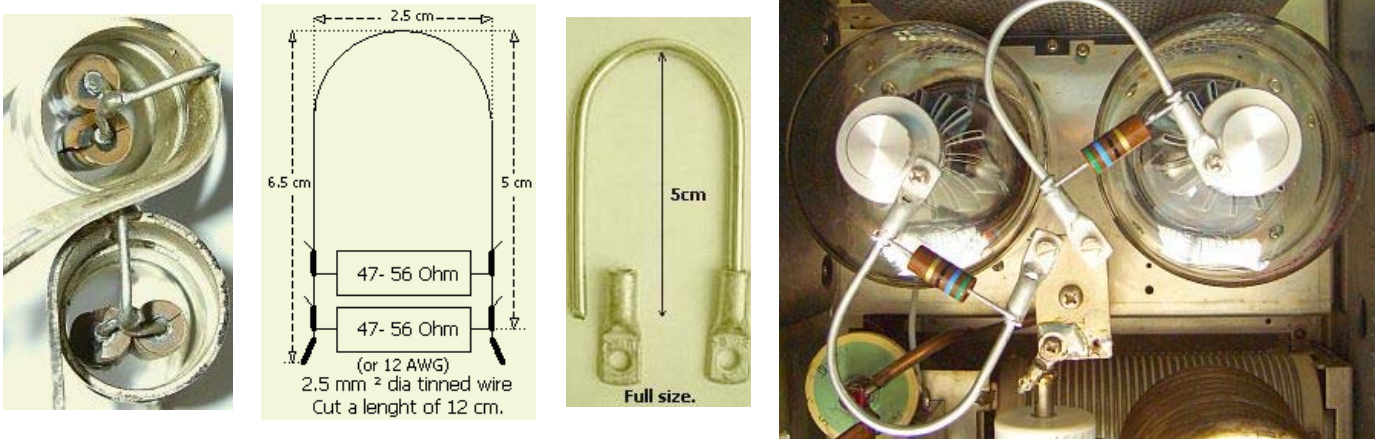
However such method can be used only where the fundamental and parasitic frequencies are sufficiently far apart, so that excessive resistive losses of the fundamental frequencies are avoided. The circuit should have a L/C ratio as low as practicable and be suitably damped to give a broadband effect.

Damping can be achieved by paralleling the hairpin circuit inductor with a non-inductive resistor and by making the inductor from resistive material. A mat surface rather than a polished surface may provide sufficient surface resistance. The resistive component need often be no more than a nickel alloy wire/strip or tinned copper wire/strip with a DC resistive value of a fraction of an ohm.



The parasitic suppressers were made from a 12 cm piece of tinned copper 2.5 mm^2 or 12 AWG wire.

The parasitic suppressors were made from a 12 cm piece of tinned copper 2.5 mm^2 or 2 mm diameter wire. The resistors of the original dampers looked a bit sad and were cracked, their shape was also in my opinion a bit small.

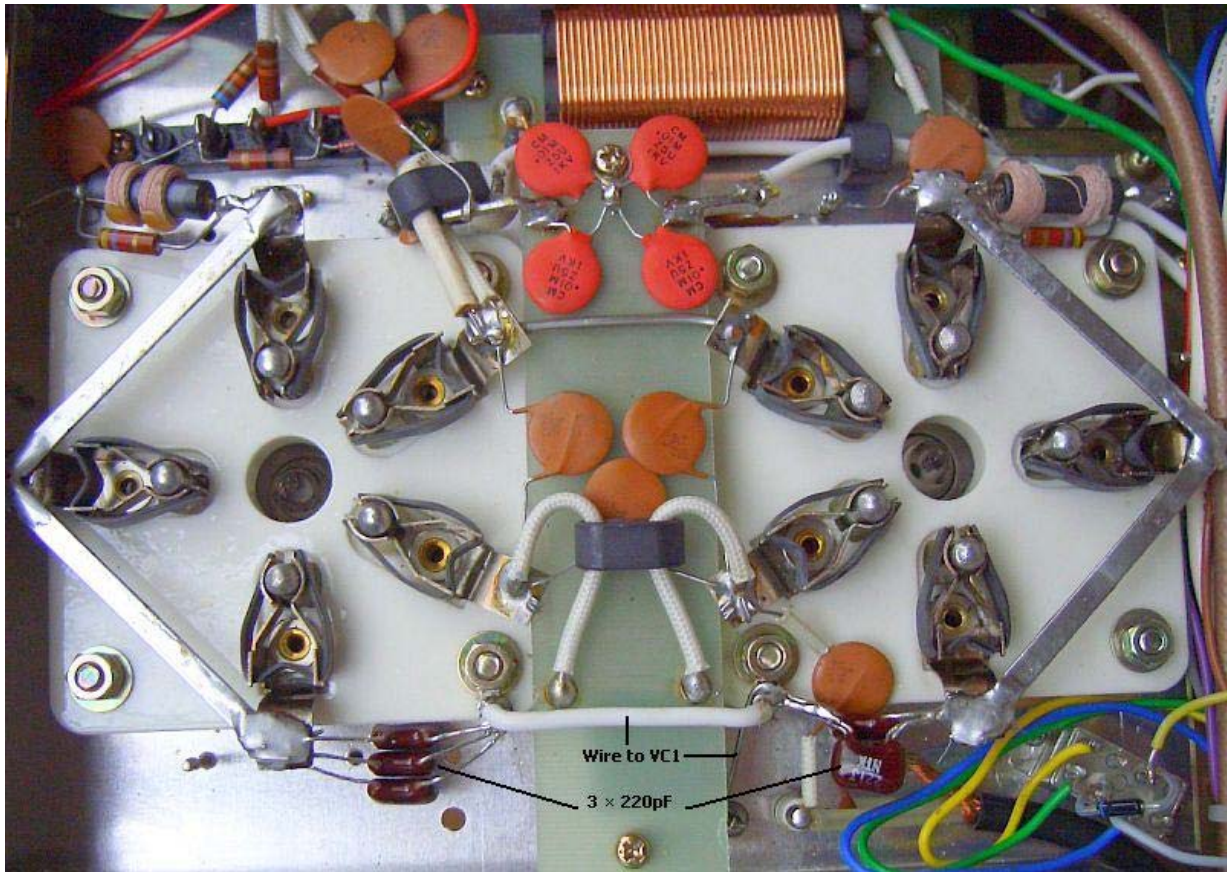


My experience with hairpin parasitic suppressors is that they work better than coiled inductors with resistors in the centre of it. All my amplifiers were done like that, so this one was done the same way. According to Richard Measures AG6K they have to be made of nichrome wire, but that is not necessary.

If you use 2.5 mm^2 or 2 mm diameter tinned copper wire, it will have sufficient skin resistance for VHF. They will be as sturdy as the original suppressors. Cut off a 12 cm long piece of wire and bend it around a piece of pipe 25 mm od., solder a lug (eye cable tag) on each end. In the US that size lug is very hard to find, however, WN4N found some made by Burndy. They are available from Graybar Electric the largest supplier of electrical construction in the US. The number is 93157387. The Burndy part number is YA8CLNT6. In the event someone needs to find these lugs you will know where they can be found.

When I think about it, it wouldn't surprise me because the way the resistors are attached, the suppressors could be effective on 2 frequencies.

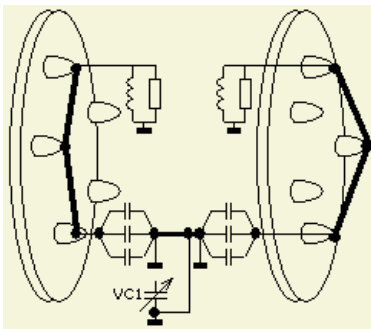
GROUND THE GRIDS ANOTHER WAY.



In my TL922 I grounded all grids original with 3×220 pf to one ground point next to the valve socket, this point is also connected via an insulated wire to VC1.

(At a later stage the decoupling capacitors were removed and all grid connections were grounded.)

My experience on HF is that it is better to connect all grid pins together and to connect only to one point on the chassis. This way a HF current is forced to go one way only which will enhance stability. When this was applied to a NEC CQ301 amplifier with $2 \times 3-500Z$, it was cured of instability instantaneously. In a different type of amp the output power increased with 100 watts on the 10-meter band.

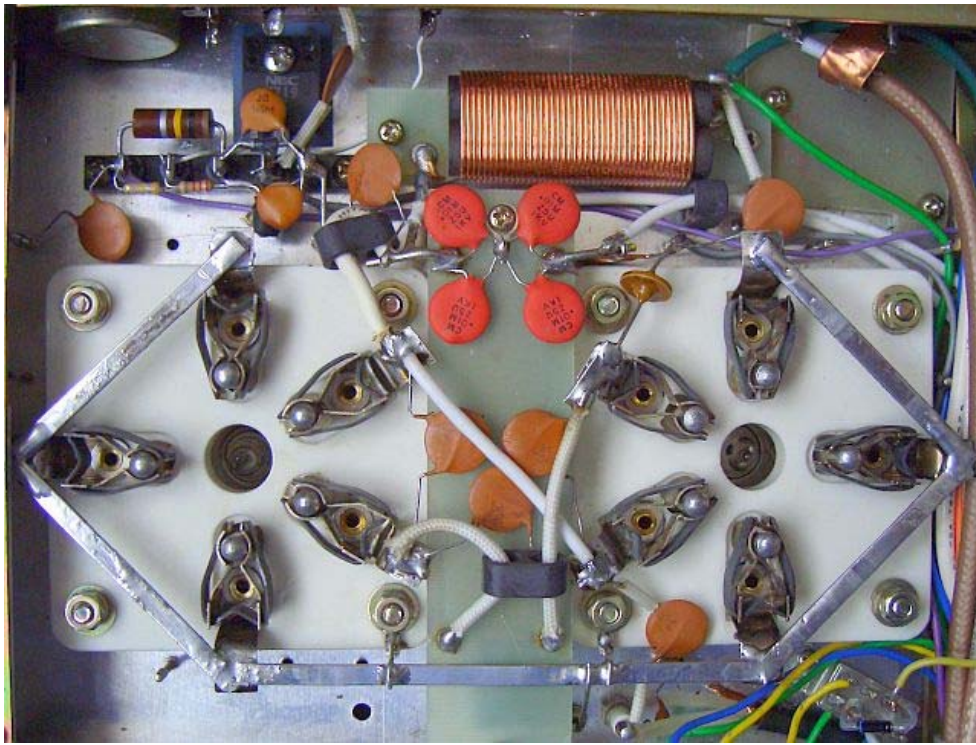


I prefer to remove all decoupling capacitors and connect all grid connections direct to ground. If you do it that way, the input impedance of the valves will change and the input inductors may have to be readjusted to $SWR = 1$.

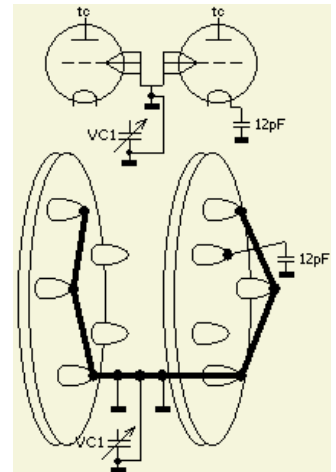
The minimal decoupling capacitance of 3×220 pf for each valve gives a negative AC feedback that makes the input impedance different then with direct connection to ground

For an improved decoupling of 80 and 160 meters of the anode choke, an extra 1500 pf capacitor was installed and grounded to the feedthrough earth wire. For the same reason a few more capacitors were added across the filament connections. Red caps. See photo.

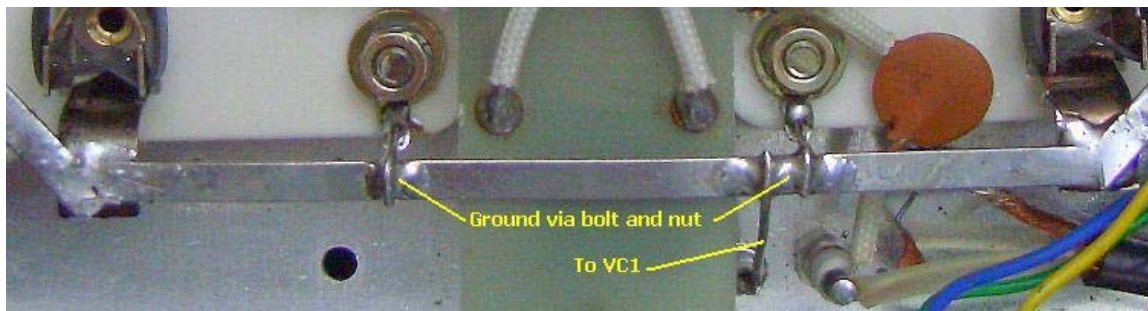




The final modification with C28 - C33, R22, R23, L7 and L8 removed.



A 12 pF capacitor was added to compensate for the removed voltage divider C40 and C41.

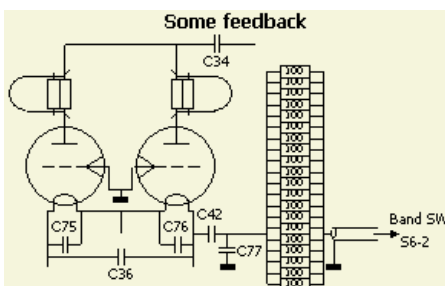


At a later stage the decoupling capacitors were removed and all grid connections were grounded. Above all expectations it worked very well and output power was increased to 1250 watts on some bands. L7, L8, R22, R23 and components from the ALC were all removed. I didn't use the latter because I never use more than 100 watts.

The old mounting strip was used for the new relay circuitry, which appears further down this article. The MosFet of this system is seen as a little black square in the left-hand top of the photo. To compensate for the removed voltage divider C40 a C41, a 12 pf was added.

FEEDBACK

If I drive my amplifier with a 100W carrier, the control grid current in some bands is more than 200 mA. That is not bad for the tubes because that is on average much less with SSB or CW.

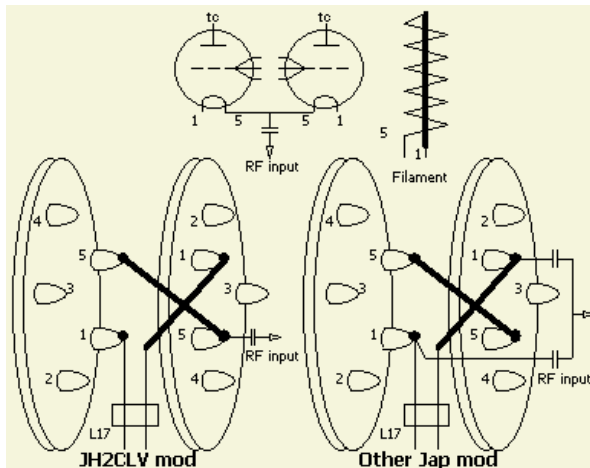


The application of feedback can make things better. This can be achieved with a non decoupled inductance free resistor of 5 to 10 ohms between C42 and the coaxial cable to the band switch S6-2. This type resistor is not easy and cheap to buy. However, with quiet a number of "ordinary" 100-ohm resistors in parallel, the total self-inductance for HF is so low that it can be neglected.

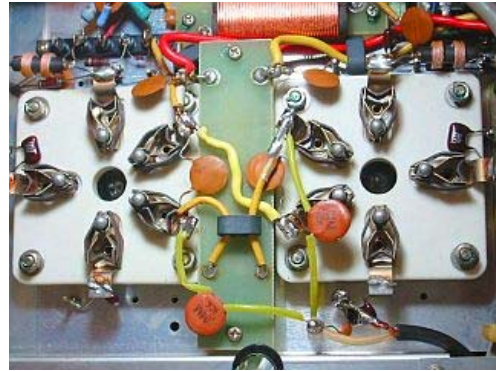


On some home pages, it is claimed that the resistor prevents random oscillations or suppresses parasites. The latter, I doubt, but if you do believe that it is a reason to mount the resistor.

CONNECTING THE FILAMENTS DIFFERENTLY



A modification of a different Japanese ham with signal on pin 1.



Different Japanese modification.

While surfing on the Internet I found the site of JH2CLV which was difficult for me to read, but I understood out of the drawings what was going on. According to this OM it is better due to the mechanical construction of the filament (fig») in a 3-500Z to connect it somewhat differently. This way the input signal appears on pin 5 of both valves instead of one valve on pin 1 and the other on pin 5.

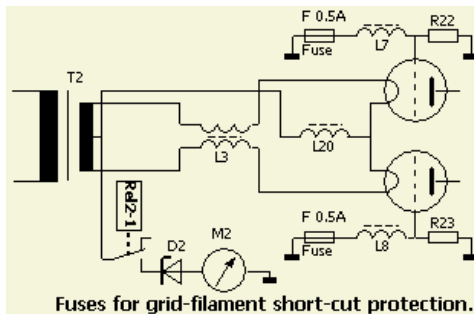
It could also be to reduce 50 Hz hums during an AM transmission or that the "wrong" connection can shield parts of the filament, so they slow down the electron flow. For the rest it isn't very clear, because on another Japanese site (see photo) the input signal is connected to pin 1 of both valves.

Assuming the drawing of the filament gives the correct picture of the real mechanical construction I'm inclined to use pins 5 for the input signal. These can be seen in the previous photo of my TL-922.

PROTECTION FOR VALVES AND POWER SUPPLY

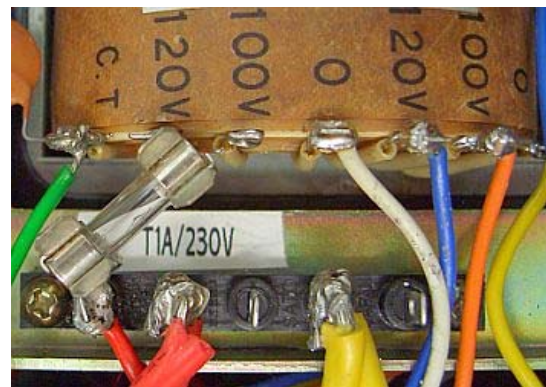
Grid chokes sometimes burn out because of instability of the valves.

That happens more to valves, which haven't been used for a long time.

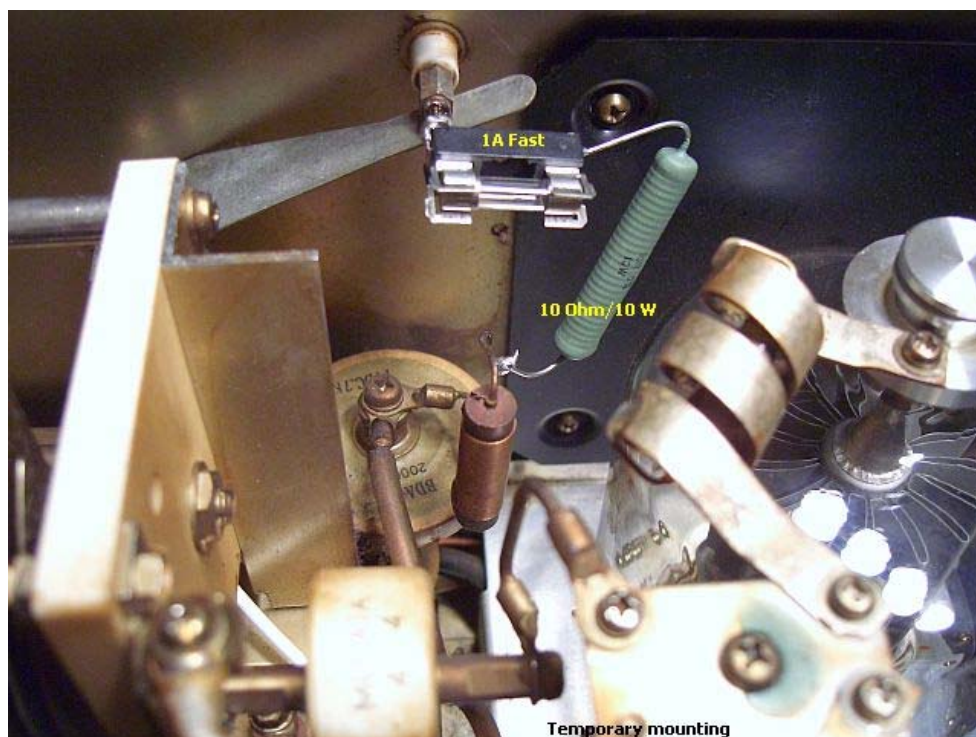


The short circuit goes via relay R2-1, the zener diode and the frame, the meter also will get a big knock.

Connecting fuses in series with grid chokes L7, L8, can make a protection. I didn't do this in my TL922, but as a preventive against grid to cathode (filament) short. I connected (see fig») a fuse on the primary side of the filament transformer.



A slow-blow fuse in the primary side of the filament transformer.



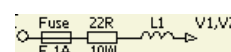
While testing I connected the safety resistor and fuse temporarily and later installed it more permanently (fig»)



I did not use L2 (12 µH).



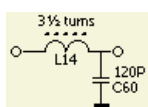
More permanent construction.



We can protect the valves and power supply against momentary shorts (ea. Flashover) by means of a resistor together with a fuse in series with the anode choke. In the photo this was done temporarily to protect and test the amplifier. Later it can be installed more permanently.

During the test a 2nd hand 3-500Z was tested for usefulness. The valve under test wasn't used for a long time. A variable transformer c was connected and the voltage was slowly increased where at a certain point a few flashovers occurred and the 1 Amp fuse was blown. This proved that the power supply was well protected. After about 30 minutes and a few more blown fuses the valve became stable, had his normal output and the plasma glow had disappeared.

INPUT CIRCUIT FOR 10 METERS



Guido ZL2VB (ex NL) wrote to me: I replaced the windings on the 10 meter input coil with 3½ instead of 2½ turns. The adjustable core didn't change the induction in the coil sufficiently to bring the SWR down. Replacing the input capacitor wasn't a good idea because it will make for a narrower bandwidth. With 3½ turns (« fig) and a 120 pf capacitor (C60) the end result was a SWR of 1 : 1.15 at the band edges between 24 and 30 MHz.

The SWR on 40, 80 and 160 meters was very good in the amplifier we tested at the time, but less so on 15 meters and not very good at all on 10 and 20 meters. Please take note, whenever you replace the valves at least on the higher bands, the input coils have to be readjusted. In my own amplifier only the SWR on 80 meters was unsatisfactory. See next chapter.

INPUT CIRCUIT FOR 80 METERS

It was found that in 2 different TL922's it wasn't possible to get the input SWR down sufficiently. This isn't accidentally but a design fault. Even with a variable capacitor instead of fixed ones, the results were not consistent. If there was a good SWR at the start of the band, it was bad at the end or visa versa. Also the length of the cable between exciter and amplifier has an influence on the SWR on all bands.

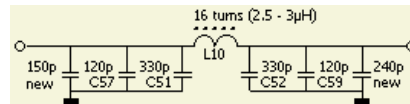
It was discussed on the Internet that what was ok for one person, didn't work for somebody else. I



blame this on variations in the way the input circuits were manufactured (fig».) The circuits are in a Faraday cage and don't allow the RF current to return to ground directly. You can put an insulated tinned copper wire through the hole where a ground pin uses to be and use this as a central grounding point (left). The best way to do this to ground all capacitors of the input filters on this earth wire. In the meantime this was only done for the 10, 15 and 80 meter input circuits.



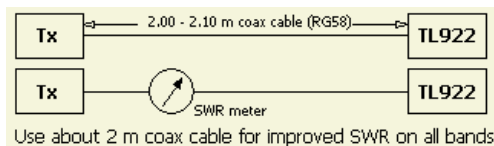
After a bit of experimenting a better compromise was reached for 80 m by removing 2 turns of L10 and to increase a number of the capacitors in parallel to the existing ones (fig »).



The range of the inductor was changed from 2.7 – 3.2 µH to 2.5 – 3 µH. If you want a different inductor value, you can calculate this with the formula $L(\mu\text{H}) = 9n^2 \times 1000$, "n" is the number of turns.

Attention: In the circuit diagram C57 and C59 is 120 pF respectively 220 pF. In my amplifier the manufacturer had a 120 pF capacitor for both C57 and C59!

WITH 2 METERS OF COAX CABLE SWR < 1.5 (also on 12, 17 & 30 meter).

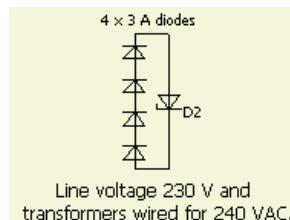


The length of a 50 Ω (RG58) coax cable between exciter and amplifier has a strong influence on the SWR. It seems that after adjusting all the input filters a length of 2 m was the optimum for all bands. That was also favourable for 12 and 17 meters because it was possible to transmit with 1000 to 1100 watts with very low SWR.

When later on all grids were directly grounded, the SWR remained the same and even went down on some bands. Only on the 12-meter band it was worse if the band switch was in the 15-meter position. So it maybe better to use the 10-meter position to get a better SWR on 12 meter.

SUPPLY VOLTAGE AND IDLE CURRENT

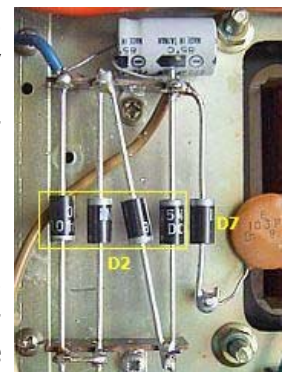
The input voltage of the power transformers can be changed either up to 240 or down to 220 Volt. The present line voltage in the Netherlands is only 228 V. If you set in the 220 V position you get more power-out, but your valve filament voltage is too high. However if you select 240 V, you will have the correct filament voltage of between 4.85 and 4.95 Volts, but your idle current will be too low. This can be corrected with 4 × 3 Amps (1N5408) diodes (in series) parallel to the zener diode D2 (7.5V). Depending on the individual 3-500Z, that could be more or less.



	L-4B idling plate current	
	CW-Tune	SSB
Plate Voltage, no load	1900 V	2600 V
Plate Voltage, load	1760 V/565 mA	2400 V/800 mA
	Idling current	Idling current
2 × Amperex 8802/3-500Z	100 mA	160 mA
2 × Amperex 8163	100 mA	160 mA
2 × Eimac 3-400Z	110 mA	170 mA
2 × Eimac 3-500Z	170 mA	260 mA

Because both 3-500ZG's are working under the same conditions as the Drake L-4B amplifier (see table), one can use the L-4B idle current for the TL922 without any problems. In my amplifier with 2 × 3-500ZG (RF PARTS) the idle current was adjusted to 190 mA. I also found an Eimac spec. sheet for the 3-500Z that advises 115 mA per valve.

In another TL-922, the previous owner removed zener diode D2 with all mechanical components and then mounted 10 diodes in series. That was a rather clumsy and mechanically unstable construction. So everything was removed and replaced (fig») by 4 × 3A diodes (1N5408) in series mounted on supports in two released holes. This lower number was necessary because the 228 V line voltage was set in the 240 V position. The idle current was about 220 mA/2400 V on load.



To prevent mistakes and to keep the wiring orderly, some people have removed the extra wiring for the change to 110 – 120 Volt. Only the 220 – 240 Volt wiring was left. This way one can wire the HV transformer for 220 Volt and the filament transformer for 240 Volt.

ANTENNA RELAY SWITCHING

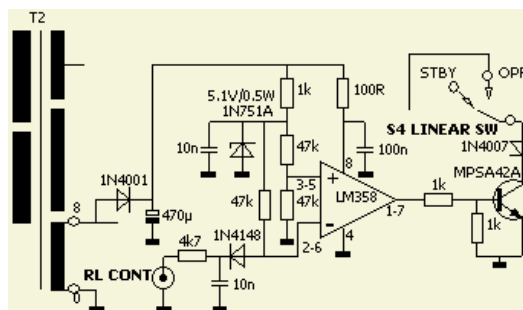
When a transceiver excites this amplifier, it has to cope with approximate 80 – 100 Volt to switch the input and output relays of the amplifier. Most modern transceivers are not suitable for high voltage switching.

Typical antenna relay switching outputs for modern exciters are: Open collector transistor or reed relay with voltages of between 12 and 48 Volt maximum and low currents. The circuit, which was used, had already been used in a modified SB200 amplifier.

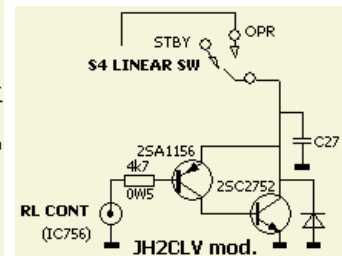
A transceiver used with this amplifier had to switch only +1.5 volt at 200 μ A. A multitude of transmitters can therefore used this way. It is still in the testing stage, but it works perfect until now. Everything is in the spot of the old ALC system (which has been removed). The 2SK719 MOSFET out of my junk box came probably out of the switching power supply of an old monitor. The specifications are $I_d = 5A$, $U_{ds} = 900$ Volt, $P = 120$ Watt and $R_{ds} = 3 \Omega$. These specifications are a bit over the top, the most you need is $I_d = 1A$ and $U_{ds} = 300$ Volt. For the transistor any universal type can be used and you can connect a diode across drain and source to limit the peak current.

You can use this with all the QSK modifications of Richard Measures AG6K.

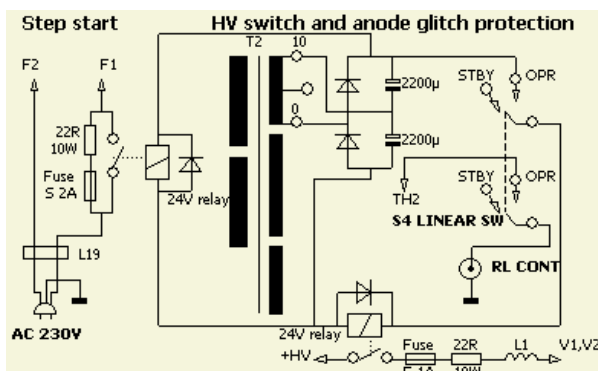
Guido, ZL2VB send me a circuit with a comparator and transistor ($V_{ce} = 300V$, $I_{ce} = 500mA$). In his design he had 2 resistors of 4.7 k Ω on pin 3-5. Because of the high input impedance of the IC I increased the resistors to 47 k Ω myself. Both circuits are made with parts out of the junkbox, other IC's and transistors can be substituted. JH2CVL does something different for a IC756 transceiver.



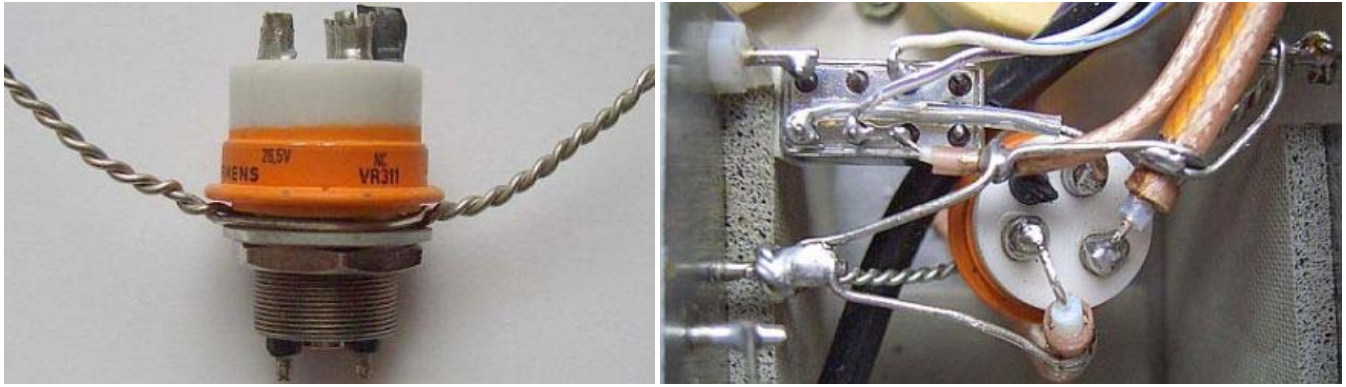
ZL2VB's modification.



EXTRA HV RELAY AND STEP-START CIRCUIT



HV Relay, according to the manufacturer the specs are: 10 mA/5 kV or 5 mA/10 kV



Simple but effective fixed to 2 soldering pins.

The previous owner had used the QSK switching of Richard Measures AG6K. That was modified and the "ordinary" 12-Volt small relay with plastic cover was replaced with a faster airtight 26.5 V/700 Ω of HI-G Co. in place of RL2. It was a relay out of military equipment.

The vacuum relay was mounted by means of two twisted copper wires and soldered to 2 existing solder points (see photo's). A simple and effective way and takes very little room. The smaller one of the relays is soldered with one pin to the input circuit, this will give together with the rest of the wiring a strong and self supporting construction. Many owners put it all on a circuit board and that will make the connection longer. With the self-supporting construction they are a lot shorter and the SWR between the transceiver and the amplifier improves on all bands.

At first I wasn't happy with AG6K's circuit, but after replacing RL2 all worked perfect even on CW.

I may replace the two 1.2k Ω resistors in series with the optocoupler with a constant current source or adjust the MosFet that way. In the meantime no other modifications are done.

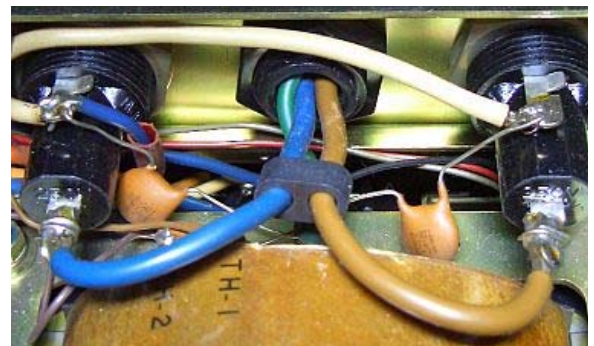
POWER INPUT DIN CONNECTOR

The big power cable of this amplifier is troublesome with experimenting and moving of this super heavy equipment and also the manufacturer predetermines its length. After some hesitation to violate a neat looking linear, it was decided to mount a DIN connector. This I do with all my equipment and it was expected that a fair bit of drilling, filing and sawing had to be done.



A punching tool set.

It would have been an extensive operation with removing some wiring and components. After taking some measurements it seemed that a 30-mm punching tool was the easiest way with very little damage and no removal of components. You can cover up the rest of the hole with a bit of black plastic.

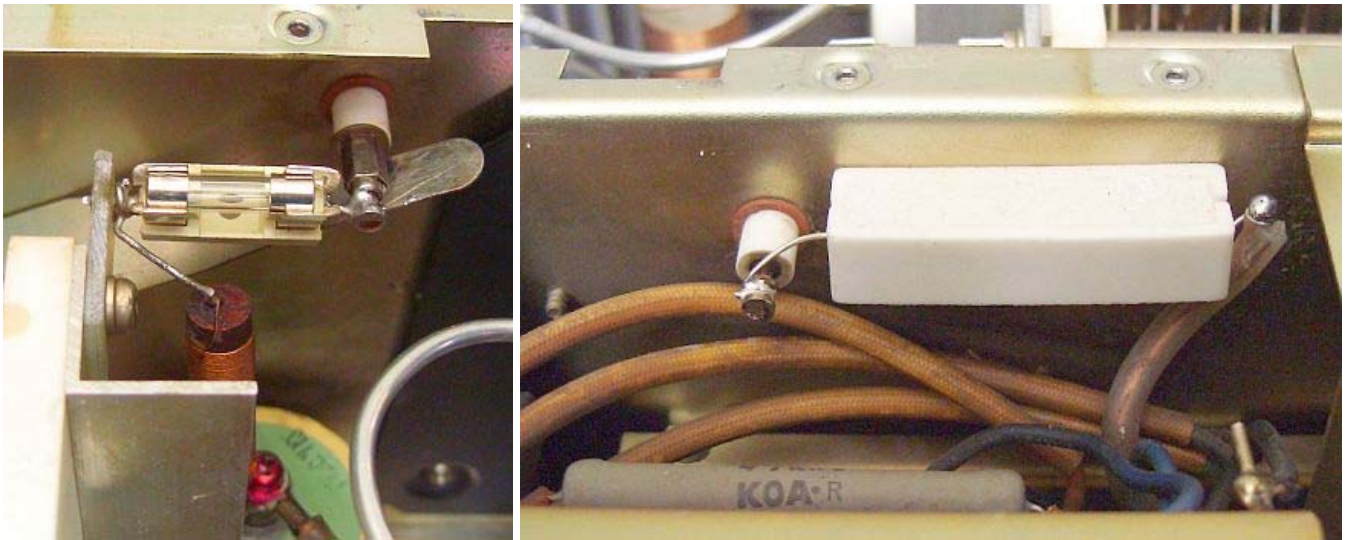


A 30 mm hole for a male DIN power connector.

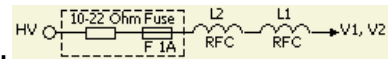
You can get these tools in different sizes, but a set of them is very handy for the DIY. They are also a lot cheaper as one tool. The set was bought last century when it was still affordable. I had a lot of use out of it.

MINIMUM MODIFICATION

For a stable and safe amplifier use the following minimal changes. Then your amplifier is protected against flashover, random oscillations and supply shortcut. If you acquired a 2ndhand TL-922 always starts with the following first modification: a resistor and fast fuse. It prevents a lot of misery as defective tubes, burned grid chokes and much more nasty events.

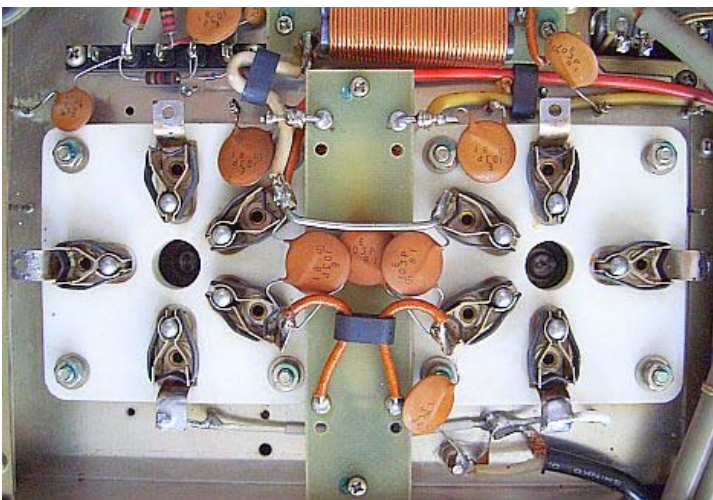


Mounting in another TL-922. The resistor was glued with Cyanoacrilate.

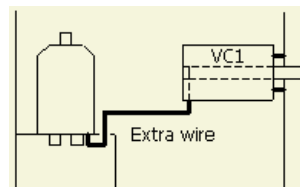
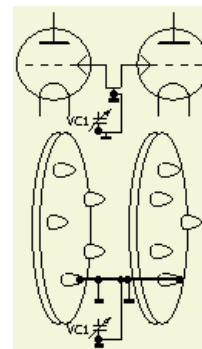


In another TL-922 I did the mounting of resistor and fuse in a different way. If the fuse blows and the lid is lifted the supply voltage is safely short circuit to the chassis. One side of the fuse holder was soldered to the supply feed-through. The other side to a tubular rivet in a slit of non cladded PCB that was fasten with a screw of the tuning capacitor VC1.

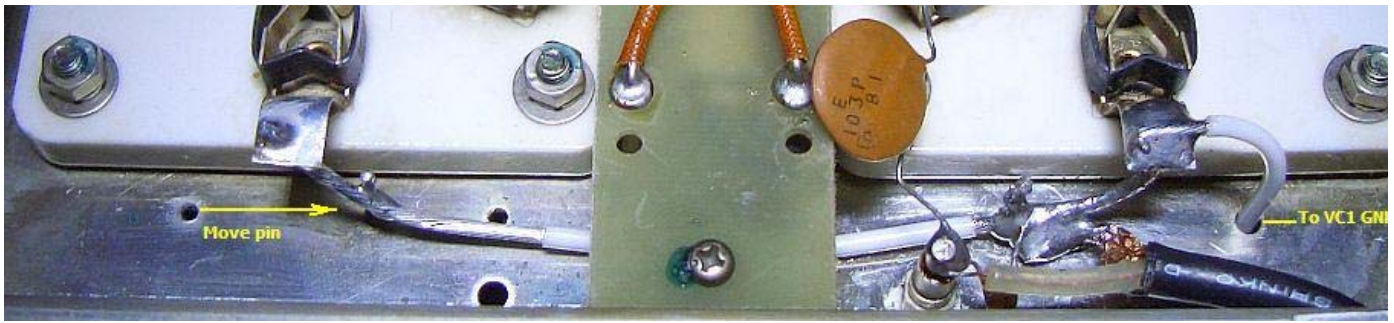
The two extra components have been useful when one of my spare tubes temporarily served as a replacement. The tube worked smoothly with a low plate voltage, but when it was increased in the SSB mode there was a flashover and the fuse blows. Without these measures, the tube was damaged by a short circuit and possibly something went wrong in the HV supply. The main fuse at the back is often too large and too slow to prevent this damage.



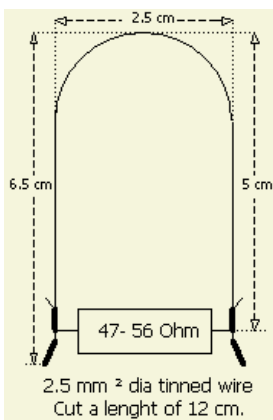
All components soldered at the pins were removed.



Connect an insulated wire from ground to (<fig) one grid p



A few years after the first modifications I thought that in the tube the 3 external grid connections are bolted to the same point. So paralleling the external pins are in my opinion for HF unnecessary. According to a law of nature RF current takes the least resistance or shortest route. It is debatable whether that is through all three pins. Just by grounding one pin the current is forced to flow via one point and that improves the stability of a tube is my conviction. Therefore, all components soldered at the pins were removed and one was grounded. An insulated wire was connected from the pin to ground of the tuning capacitor VC1.



The parasite suppressers work well with one resistor and it was tested in this amplifier. The open end of the hairpin was taken little wider for good alignment between tubes and the plate choke.

After the modifications the amplifier worked stable and just as good as my own linear.



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