BY TOM SNAKES

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1. An unusual splitter circuit

After a review of my circuit archive I found a copy of an article from a French electronics magazine 1 , In turn, another article from an American magazine 2 was summarized. The French article was entitled "Un Inverseur de phase améliore" what I just now could translate, with "An improved splitter" to me.

Furthermore, I stood in the articles in the diagram in Figure 1.1 eye, and I tried to understand what (according Revue du Son) or even "new" (according to title of the original article by AR Bailey) should be on it except "improved".

Not least because of us German rather unusual French drawing methodology I realized in the original diagram at first only a fairly ordinary input stage for low voltage gain in Pentode circuit and then, with respect of what follows in this preliminary stage, first only "station", where the splitter portion but immediately the use of two different tube systems - a pentode and triode - catches the eye.

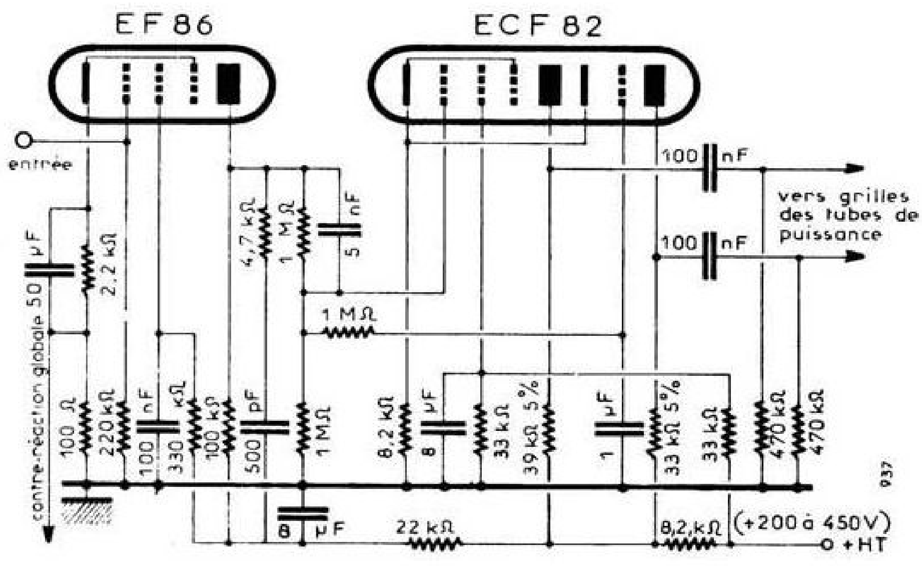

Figure 1.1: Splitter by AR Bailey

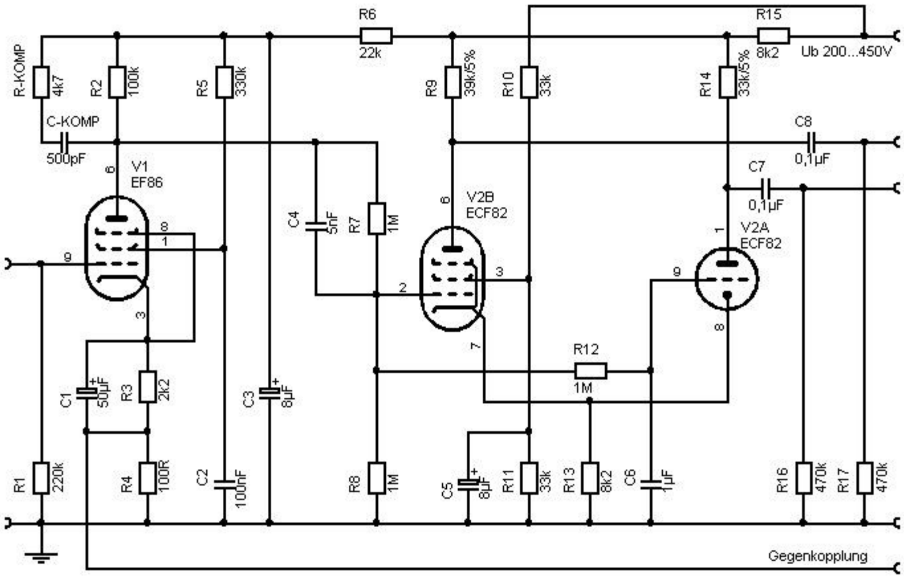

Figure 1.2: Schematic of same circuit

As you can see the French have a very different, not to say a bit random seeming idea has to look like a diagram. I have therefore the circuit diagram in Figure 1.2 slightly redrawn, so that we get a better overview.

But even now the diagram looks rather unusual and so the next step is to break it once in its main functional units, namely, the input stage and the actual phase splitter part, and these go through individually.

1.1. The input stage.

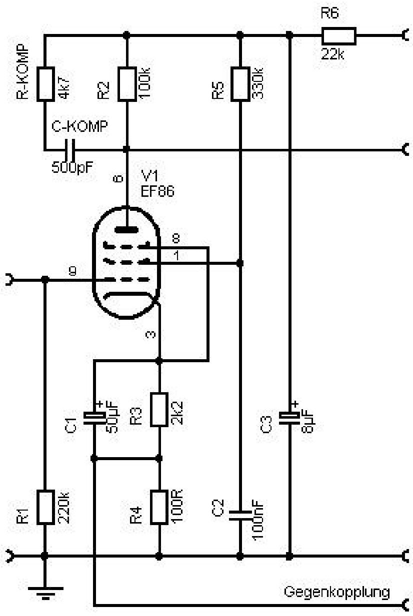

Figure 1.3: The input stage

In the input stage, shown in Figure 1.3 , Is an ordinary small-signal voltage gain stage in Pentodenschaltung with an EF86, as it can be found in countless audio amplifiers. It therefore remains for the time being noted very little:

- The input is performed without isolating capacitor, which is rather unusual for that time, but results in improved phase behaviour.
- The parallel to the load resistor R_2 connected RC combination consisting of R_{comp} and C_{comp} is the stepped height reduction and phase correction and the dimensions shown making only in direct connection with a following on the circuit push-pull output stage and things, concrete output transformer sense.
- The power supply is decoupled via an RC combination R_6 and C_3 of the following stages.
- The voltage divider ratio R_3 to R_4 in the cathode strand is 22: 1 selected very high and the alternating voltage decoupled with C_1 of the string is therefore negligible. This suggests that the precursor is primarily designed to a very high levels gain.
- No action is seen, which would support operation over the still very wide supply voltage range of the overall circuit.

All in all, therefore, a fairly conventional small signal amplifier stage with the EF86 as from the data sheet or textbook.

1.2. The splitter part.

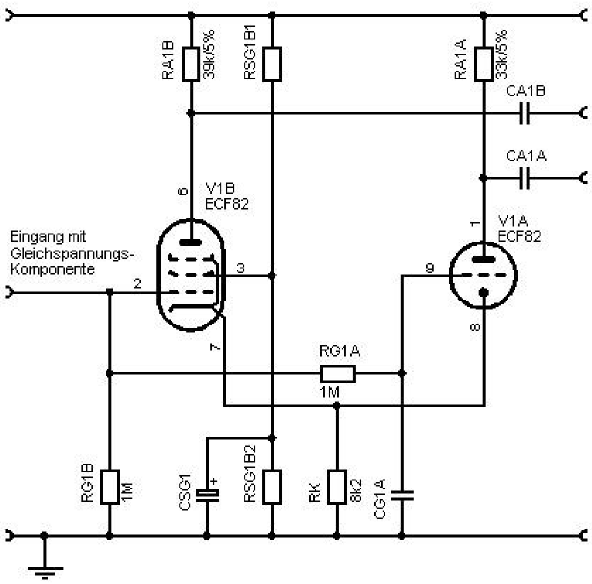

Figure 1.4: The splitter part, somewhat simplified

Let us look at the phase splitter, which was also extracted for clarity from the general diagram and somewhat simplified and in Figure 1.4 is shown. There are just some unusual details on:

- It is a composite Noval tube ECF82 3 which have two different systems includes: A small sign Alps death at the entrance and a Klein signal triode at the second output,
- the load resistors and Ra1a Ra1B are different,
- the power of the screen grid of small Sign Alpen death is as a voltage divider comprising resistors R_{SG1B1} and R_{SG1B2} and the screen grid is AC-wise not blocked against the cathode, but against circuit ground,
- both systems of ECF82 have a common cathode resistor,

- the control grid of Klein signal triode is AC coupled to ground blocked, obviously this stage thus operates in grid-based circuit. That is, the unit is controlled via the cathode of the two systems and Triodensystems common cathode resistor $R_{k.}$

Although the last two points suggest in principle on a splitter circuit similar to the so-called "Long tail pair" toward which became popular through the push pull amplifier of the Mullard. On the other hand suggest other points towards a significantly deviating from the "LTP" operation, such as the different tube systems and load resistors and the unusually small common cathode resistor $R_{k.}$ If you look at something in the literature in order, then it can be seen that the present characteristics - except for the different tube systems - the so-called Schmitt splitter 4 correspond. If we follow this path so once more.

1.3. Basic operation of a Schmitt-phase splitter.

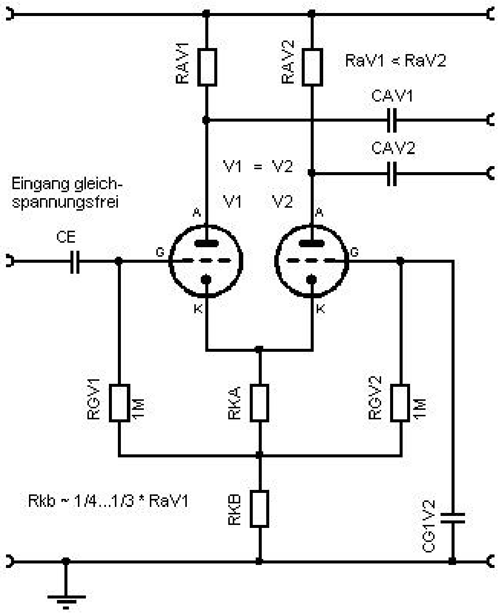

Figure 1.5: Schematic diagram of a Schmitt-phase splitter

A further simplified schematic diagram of the Schmitt phase splitter is shown in Figure 1.5 reproduced, the similarities to the Mullard circuit are not to be overlooked. However, unlike the classic Mullard circuit of Schmitt-splitter not even the best possible symmetry of the outputs on identical as possible tube systems attempts, as similar as possible (being measured) anode resistances and the greatest possible common cathode resistor ideally even running a constant current sink, brought to lead.

1.3.1. Operation. For simplicity it is assumed that the same tube systems for V_1 and $V_{2.}$ The input system V_1 operates in principle in cathode base circuit having a divided and decoupled cathode resistor, wherein the upper, smaller partial resistor of the cathode resistance $R_{n,}$ is used for automatic bias and the lower, larger partial resistor R_{kB} as an additional cathode working resistor (cathode follower function) is executed. This is at the cathode of V_1 a very low impedance, non-inverting signal output available, which drives the low-resistance cathode also the in grid base circuit operating with alternating voltage grounded control grid tube system $_{V2.}$

Since the lattice base circuit to V_2 is not inverting, is therefore available at the anode of V_2 in phase with the amplified input signal is available (non-inverting output of the circuit) and the anode of V_1 is the inverted and reinforcing the cathode base circuit input signal (inverting output of the Circuit).

Going back to the first stage. The step gain of a cathode follower, in this case formed with $V_{1,}$ R_n and $R_{kB,}$ is always less than 1, thus the V_2 driving signal is applied to the cathode of the grid base circuit also necessarily smaller than the control grid of V_1 applied input signal. Since the common, uncoupled cathode resistor R_{kB} is now deliberately relatively small dimensions - typically only a quarter to a third of the value of the load resistor of the input system - the cathode output of the system V_1 is even much smaller than the input signal at the control grid of $_{V.\,1}$

The inevitable result resulting asymmetry of the output voltages at the anodes of V_1 and V_2 must therefore be balanced and this is done by deliberately different oversized anode resistors $R_{aV\,1}$ and $R_{aV\,2}$ wherein $R_{aV\,2}$ in the same tube systems larger than $R_{aV\,1}$ to is select to obtain a higher voltage amplification through the unit $_{V2.}$

1.3.2. Advantages and disadvantages. One naturally wonders actually against the similar but equal bred on the best possible symmetry LTP or the Mullard circuit provides the advantages of Schmitt splitter. Now, these are quickly enumerated: Since the Schmitt inverter, the common cathode resistor R_k compared to standard Mullard circuit 5 chosen deliberately small, fall on this and only a comparatively small (corporate) from voltage. This means, conversely, that the Schmitt inverter more tension on the tube systems and anode resistors available than at the Mullard circuit, and ergo the same supply voltage U_b a higher undistorted output voltage and possibly higher stage gain than the Mullard circuit possible is.

This compares to negative, that the correct dimensioning of the Schmitt inverter is slightly more complicated and that the two outputs necessarily have different output impedances due to the differential anode resistors. The latter is possibly just to be considered in the overall concept of an amplifier circuit as well as when using other phase splitter circuits with different output impedance 6 at the outputs.

1.4. Intricacies of the present implementation.

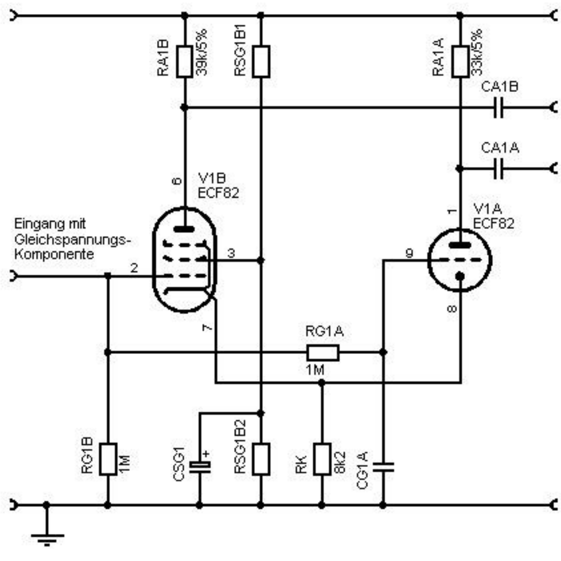

Figure 1.6: Schmitt inverter to Bailey

Now let's look at the actual design of the circuit by Mr Bailey, again shown in Figure 1.6 And they look for specific intricacies through.

The most striking point is the use of different tube systems of the circuit according to Bailey. The main reason of using a pentode as an input system of the phase splitter is their extremely low input or Miller capacitance, which with precursors rather high output impedance guarantees a very high bandwidth itself.

This way, a major problem of the Mullard circuit is bypassed, which also like the Bailey circuit uses a pentode before the actual phase splitter, which has but to drive the Miller capacitance of the subsequent ECC83 in LTP, which, assuming a step gain of the LTP of approximately A = 30 is no less than 50pF, and more.

Now, the internal resistance of a pentode is generally much greater than that of a triode, as the voltage gain and, unfortunately, the distortion factor. Bailey now uses various tricks circuit back to obtain the desired low Miller capacitance of the pentode, but lower at the same time gain, output impedance and distortion, and thus adapt to the parameters of triode section $V_{1\ A}$ of ECF82:

- The comparatively small load resistor $_{Ra\ 1\ B}$ = 39 k Ω reduces the stage gain and output impedance. The output resistance of a pentode in cathode base circuit can be approximated with Z ≈ $_{from\ Ra}$ and is this measure alone already dimensionally in the field of Triode systems $V_{1\ A.}$
- By the non-coupled cathode resistance $R_{k,}$ there is a counter-cathode voltage and thus gradually local feedback for the pentode $V_{1\ B,}$ but which again raises the step gain and the distortion level lowers, the output impedance of something.
- Since the cathode of the pentode $V_{1\ B}$ moves in phase with the input signal at the control grid, screen grid alternating voltage but to circuit ground (and not against the cathode) is blocked, there is a further step local negative feedback via the screen grid which stage gain and distortion lowers again.

All in all the pentode is approximated by these measures on a triode or similar behavior regarding harmonic distortion, output impedance and gain stages in the splitter, but at the same time the advantage of extremely low input capacitance of Pentode circuit remains.

Another point worth noting is the screen grid voltage supply of the pentode, which does not take place as usual mostly only a simple resistor and blocking capacitor, but by a real voltage divider consisting of the resistors R_{10} and R_{11} in Figure 1.2 , Dimensioned to each 33 k Ω, so with a fairly high crossflow. These resistors hold the screen grid rigidly to $_{1/2}$ of the supply voltage $U_{b,}$ which may be between 200 and 400 volts, according to the original diagram yes. This measure ensures that the pentode is always operated above the allowable but very wide supply voltage range in a favorable characteristic field, which would be with a single, simple resistor probably unreachable.

As a final point it should be mentioned that the specific circuit design as shown in Figure 1.6 of the basic circuit of a Schmitt-phase splitter according to figure shown above 1.5 far different than that of the two systems of grid bias ECF82 is not generated automatically as in the basic circuit diagram of a split cathode resistance, but semi-automatic with an additional DC component, which is removed from the anode of the previously previous stage. This also contributes to the further stabilization of the actual phase splitter part of the circuit over a wide supply voltage range.

1.5. . Summary and Evaluation The present circuit according to Mr Bailey is certainly not easy and simple to name, but has over the classical Mullard circuit (EF86, ECC83 in LTP), the reference to the circuit analysis comprehensible advantages:

- to stably operate over a wide supply voltage range and to be usable,
- to provide a higher output voltage at the same time significantly lower output impedance at the same supply voltage,
- to permit due to the pentode is the first system in the phase splitter in principle a higher cut-off frequency, or alternatively to produce less phase response errors at the same frequency to be transmitted.

Especially the former two points raised in permit virtually unchanged circuit using the same different before so in terms of performance as standard supply voltage power tubes like EL84 at the bottom up to the KT88 at the upper end.

Is therefore not surprising that these same circuit discussed is found to be almost unchanged module in several amplifiers of the power rating of the renowned manufacturer Radford. Maybe AR Bailey has this circuit for Radford designed or even work directly in Radford.

(Tom snakes, March 2008)