NOISE SILENCERS — A developmental model

Last August we presented a noise silencer based on the well known Lamb principle. This used modern valves and was designed to be fitted as an outboard unit to existing short-wave and communications receivers. However, the need still exists for a silencer suitable for use in solid state receivers. Here is one version of such a unit which we developed during our investigations.

By Ian Pogson

The silencer we are about to describe was evolved during our work on the new short-wave receiver currently under development. While it works extremely well, and we have presented enough information to allow any reasonably experienced reader to duplicate it, we should emphasise that it is only a developmental model. Even as we prepare this article, another unit is under development. While it is unlikely to function any better, we hope that it will offer the advantage of greater simplicity, fewer components, and smaller physical size.

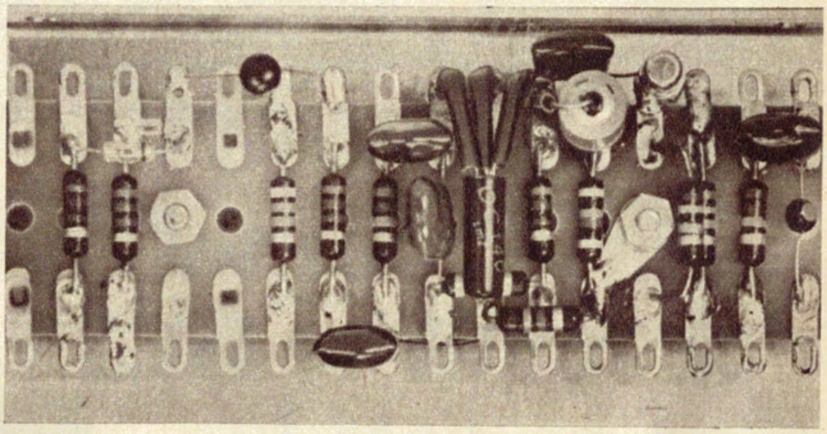
In our earlier article we went into some detail regarding noise, together with possible ways of dealing with it. We do not propose to go over this ground in the same detail again. Rather will we summarise what has already been said. Readers who may wish to refer to the previous article can find it in the issue for August, 1969.

The noise we are considering is that received by the aerial system, rather than any generated within the receiver or which may find its way into the receiver via the power mains.

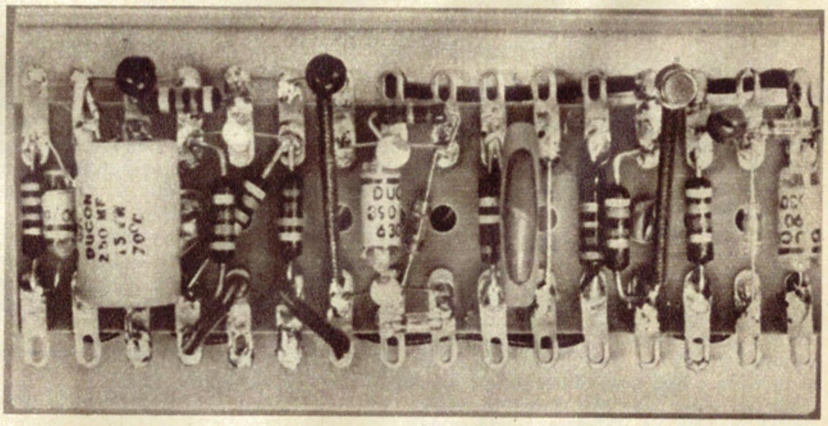
Man-made noise comes from neon signs, arc welders, switches, domestic appliances, high tension power line leakage, car ignition, etc. Atmospheric noise results from lightning discharges often referred to as "static." Galactic or cosmic noise emanates from outer space.

Noise can be divided generally into two groups, hash or hiss in one instance and impulse in the other. Hiss is more or less random pulses which are continuously overlapping. Impulse noise is quite different, being normally of very short duration and high amplitude. This latter type of noise is much easier to deal with than the former.

For the benefit of readers, we are repeating the block diagram which was used for the previous article. Between the mixer and first IF amplifier, and ahead of any highly selective circuits, there is a "gate." From the mixer are taken the signal and noise, which are passed through an amplifier. This is followed by a detector or rectifier. The amplifier is biased by a gain control. This is so adjusted that the two circuits combine to separate the signal from the noise pulses, by reason of the greater amplitude of the latter. As a result, pulses only, caused by the noise, emerge from the detector.



This photograph of the "signal path" board should be studied and correlated with the wiring diagram shown on page 81. The emitter-follower stage is at the right, with the gating transistor next and followed by the amplifier and switching diodes at the left.



The reverse side of the assembly, this board contains the noise amplifier at the left, followed by the phase-splitter, detector and pulse amplifier at the right. This should be studied with the wiring diagram on page 81.

The pulses are then passed through an amplifier and, from this, are fed into the gate. The pulses are of such polarity as to close the gate for the duration of the pulse.

As the ratio of the duration of a noise pulse, to the time between pulses, is generally quite high, the signal through the gate is cut off for only a very small percentage of the total time.

Apart from their effect on readability, noise pulses have the additional effect of actuating the A.G.C. system and desensitising the receiver accordingly. In extreme cases, this can reduce the receiver sensitivity to a point where the signal is inaudible for this reason alone.

Although the Lamb system is most effective in the fight against impulse type noise, it can often be used to at least reduce the nuisance of other types of noise. Also, as the silencing occurs early in the IF system, noise which would otherwise desensitise the receiver is eliminated or reduced.

Having met with such success with the valve version we thought it worthwhile to try to develop a solid state version. This presented a number of problems, a prime requirement being that the silencing circuits should not take up more than their fair share of space. In the valve version the components taking up the lion's share are the valves and the IF transformers. While the valves will be eliminated, the transformers are still a problem.

Considering, in turn, each transformer as used in the valve system, we debated whether we could dispense with it. The transformer normally fitted to the input of the silencer was the first to be considered. A major function which this transformer nomally performs is that of filtering out any local oscillator signal which may appear at the output of the mixer stage. Without this filtering action, local oscillator signal can reach the gate circuit and seriously upset its operation.

However, the receiver with which this silencer was intended to be used was a special case. It features a double balanced or "ring" mixer, a major characteristic of which is that very little local oscillator signal appears at its output. For this reason we felt that the transformer might possibly be omitted. Assuming that it could, the arrangement would have the additional advantage that there would be no tuned circuits to degrade the noise pulse — by lengthening it — before silencing.

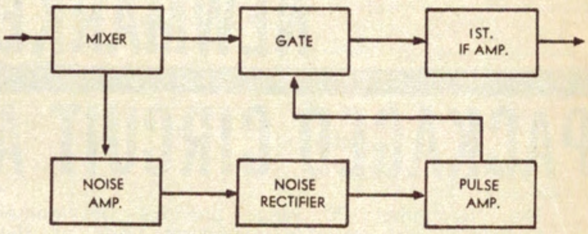
As it turned out, the idea worked, but we must emphasise that it is suitable for use only with mixer systems which have a very low local oscillator output. Where more conventional mixer systems are used it will almost certainly be necessary to fit a transformer, undesirable though this may be in regard to its effect on pulse duration. The best compromise is to damp the tuned windings as much as can be tolerated in order to minimise the effect.

The next transformer to receive attention, was the one between the noise amplifier and the detector/rectifier circuits. In addition to being an impedance changing device, it also functions as a phase-splitter. We reasoned that a transistor phase-splitter could be used here.

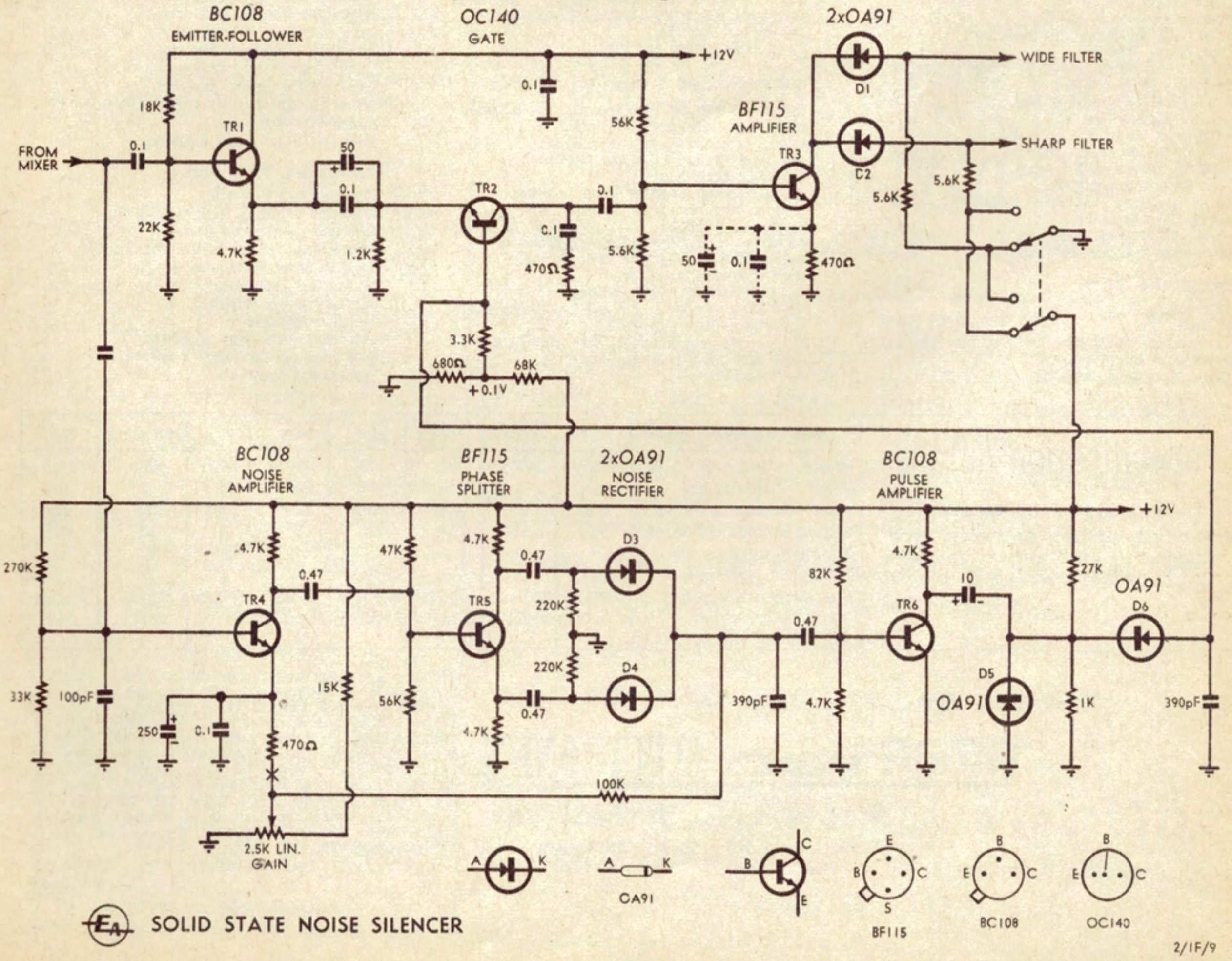
In theory at least, we were doing quite well thus far. However, the gate circuit, with its input and output transformers, presented a more difficult problem. Fortunately, our attention was drawn to an unusual type of gate, used by William K. Squires in his noise silencer (QST October, 1963). This gate, which uses a symmetrical transistor, is an unbalanced arrangement and needs no input or output transformers. This seemed to be the answer. Although the symmetrical transistor used by Squires (RCA 2N-1169) is not available in Australia, we were able to obtain some near equivalent types offered by Mullard.

A symmetrical transistor is one in which both emitter and collector junctions are the same physical size. While, electrically, these are the same as a normal bi-polar transistor, the identical emitter and collector junctions produce a relatively low-gain device which, however, has useful characteristics in

This block diagram will serve to refresh the reader's memory regarding the basic operation of typical noise silencers. Compare it with the circuit below.



Circuit diagram of the developmental noise silencer. Note that no transformers have been used but that an input transformer would be necessary when used with the more conventional mixer circuits. Components shown dotted will provide additional gain.



other respects. Its main use is in high-speed switching circuits in computers. Also, although the Mullard types are coded to indicate "emitter" and "collector" in the usual way, the leads may in fact be reversed and the device will function equally well.

Having dispensed with the transformers in a theoretical design, we had to make up a practical unit. The circuit diagram shows the end result and we will go over it and explain the various functions.

At the silencer input, the signal is split. Part is directed via an emitter-follower to the emitter of the symmetrical transistor, or gate. The gate is connected such that the signal passes from the emitter to the collector. The emitter junction is forward biased with about 0.1 volt and emitter current flows under these conditions. It will be noted, however, that there is no provision for collector current. The output of the gate is terminated with a 0.1uF capacitor and a 470 ohm resistor in series, and the input resistance of the following transistor amplifier. This amplifier is needed to make up for the insertion loss of the gating circuit.

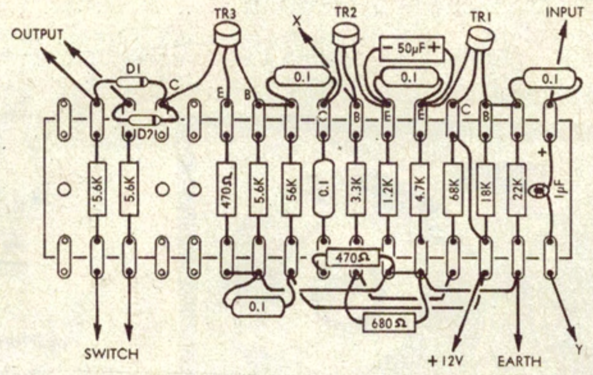
At the output of the amplifier there is provision for diode switching the signal into one of two channels. These provide filters having two selectivity band widths. This may be omitted, using a single 5.6K resistor for the amplifier collector load.

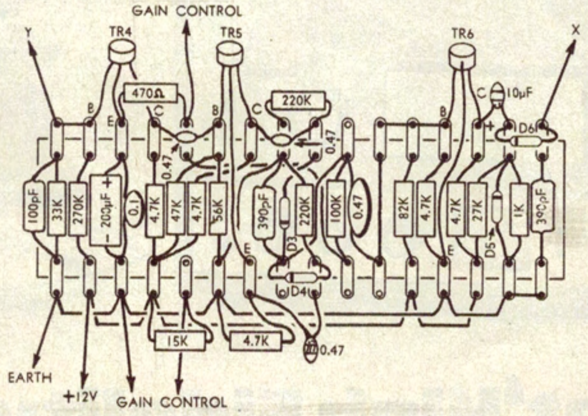
Returning to the input, the other split feeds the noise amplifier. The function of this amplifier is not only to amplify the noise pulses but also to separate, from the signal, those noise pulses which are of greater amplitude than the signal. This is done by so biasing the amplifier that it will not pass the wanted signal, but only the noise pulses above a predetermined level.

The noise pulses are passed to the phase splitter which, in turn feeds a full-wave rectifier. In addition to the separation of noise pulses from the signal, within the noise amplifier, this process is augmented by the fact that the rectifier diodes are also reverse biased by the same control.

Positive-going pulses which emerge from the noise rectifier are, in turn, fed into a pulse amplifier, so biased that it is just in conduction without any signal. Due to the phase reversing characteristic of the common-emitter configuration, negative-going and amplified pulses are produced at the collector of the pulse amplifier. These pulses, after being subject to clipping by two diodes, are fed into the base of the symmetrical transistor gate. This closes the gate for the duration of the pulse, preventing any signal from passing for this period.

This circuit, while it performs very well, could be still considered as developmental. It will be noted that there is a 50uF electrolytic capacitor across the 0.1uF blocking capacitor, between the emitter follower and the





The upper diagram on the right shows the layout and wiring of the "signal path" board. Compare it with the upper photograph on page 78.

The board in the lower diagram carries the noise amplifier, phase-splitter, detector, and pulse amplifier. See lower photograph, page 78.

gate. More than likely this 50uV capacitor could be dispensed with, as its presence is perhaps more academic than necessary. A similar condition exists with the 250uF capacitor which by-passes the 470 ohm resistor in the emitter of the noise amplifier.

Also, when used with some receivers and depending on signal levels and other conditions, some minor changes may be necessary. The amplifier following the gate is normally operated without an emitter by-pass, the limited gain resulting from this degenerative circuit being normally quite sufficient to make up for the insertion loss of the gating system. However, if more IF gain is desired the 470 ohm emitter resistor may be by-passed with a 0.1uF capacitor (shown dotted). The 50uF electrolytic is an academic addition and probably will not be needed.

Again, depending on the actual receiver with which it is used and/or due to high signal levels, there may not be enough control afforded by the 2.5K gain control in the noise amplifier stage. Rather than increase the emitter junction control voltage, some degeneration can be automatically introduced by returning the emitter resistor by-pass capacitor(s) to the other end of the 470 ohm resistor, rather than to earth.

In some cases even this may not provide sufficient control in the presence of large signals. With signals of this magnitude it is unlikely that the silencer will be needed, but it is necessary to be able to control or disable the noise amplifier. A switch on the 2.5K pot can be used to break the circuit at point "X."

The reason that it is necessary to reduce the gain of this amplifier so drastically is that the system becomes "suicidal" if the amplifier is allowed into pass more than a small predetermined level of wanted signal. If passed, it will be rectified, amplified in the pulse amplifier and then as negative pulses from the wanted original signal, will close the gate and produce a "lock-out" condition.

The transistors shown on the circuit diagram are those we used in the prototype. They consist of random positioning of BF115 and BC108 types. Although the BC108 is intended for audio use, it performs quite well at least up to 455KHz. Such others as SE3001, 2N3565 and similar types may be used without difficulty.

The symmetrical transistor is a Mullard OC140. This does the job adequately. However, there are three different types in a series offered by Mullard. These are the OC139, OC140 and OC141. They differ from each other mainly in the gain characteristic. The OC139 has the lowest gain, followed by the OC140, with the OC141 being the highest. The price of the OC139 is the lowest, the OC141 the highest. As far as we can ascertain, the OC139 should do the job adequately and there is no point in paying more for the others.

The capacitors are not critical as to type. The lower values could be mica or polystyrene and the mid values either low voltage ceramics, such as the Redcaps, or low voltage polyesters. In the prototype, for values from 10uF, to 0.47uF, we used tantalum types, but this is not necessary. We used them simply because we had them on hand. An exception to the use of tantalum or other polarised capacitors, as mentioned above, is the 0.47uF coupling capacitor from the output of the noise rectifier. The voltage across this unit can reverse and so a ceramic or polyester must be used.

We built this unit in modular form, along the same lines as the IF strip described in the issue for November. The general idea was to make it so that it could be used in the complete solid state receiver on which we are currently working.

Two lengths of miniature tag board are used, each with 16 pairs of tags, mounted either side of an aluminium panel. On one side, we have the emitter-follower, the "gate," the amplifier, and provision for diode switching. In short, this panel contains the IF signal circuits.

The other panel consists of the noise amplifier, phase splitter, noise rectifier and pulse amplifier. The components on each board are so located that they follow a logical order with respect to each other—in much the same way as the circuit is drawn.

Assembly and wiring are simple and straightforward and are made even easier with the wiring diagrams. The usual care should be taken with soldering, making sure that there are no dry joints. At the same time, overheating of all components, particularly the transistors, should be avoided.

When mounting and wiring those components which fall at four lugs in from each end on each board, provision must be made so that fixing screws and nuts can be passed through. Also, under the screw adjacent to the emitter-follower on one side and the noise amplifier on the other side, we have provided a solder lug, which is soldered to the nearest earth connection in each case. When the unit is completely assembled, these lugs ensure that the appropriate circuits are bonded to the chassis or frame of the receiver.

The aluminium panel is 4in long, 2in high and fitted with a 5/16in mounting foot. Holes corresponding to the fixing screw positions are provided, together with three more holes for leads to pass from one board to the other. These leads are an interconnecting earth, positive 12 volts supply, and the lead from the output of the pulse amplifier to the base of the gating transistor. These holes may be drilled at any convenient positions, at the discretion of the builder.

When completed the solid state silencer is ready to be fitted into a receiver. No alignment is needed, as there are no tuned circuits. The only possible adjustments are those associated with high signal levels, as mentioned earlier in the article.

Tests and measurements have shown that this silencer is capable of operating at very high speed and excellent results can be expected when used with noise of an impulse nature. As mentioned previously, this unit has only just been developed. It is presented at this early stage with the idea of giving readers new food for thought on the noise combating front. No doubt, many readers will already have an application for such a device, either in its present form, or perhaps with some changes which may suggest themselves for a particular application. ■