He almost always got to within 0.5dB, but we always managed to make a slight improvement with the HP system. Don't forget that you might not need all the gain that you can get, so you might make a useful improvement, if you can spare some gain, by loosening the output tuned circuit coupling, this also usefully increasing the Q of the output, which helps to keep out signals outside the band.

Noise figure and gain

We measured most of the preamps initially with a manual analogue system, including a Rohde and Schwarz *SKTU* noise figure source/meter, Andrew's *FSJ4* connecting cable, a 3dB pad, a very accurate 50 ohm screened input termination, with a Microwave Modules transverter down to an Icom *IC740* HF rig with the audio feeding a Bruel and Kjaer true RMS audio volt meter. The precise attenuation of the input lead, 3dB pad and adaptors was measured using a Marconi *2019* signal generator and a Racal RF power meter. We found that we got more accurate results by setting the noise-off level using the 50 ohm input termination, rather than turning the 'off' switch on the noise source, although there was only a minute difference. We increased the level of noise until the audio output noise power increased by 3dB within the pass band 300Hz to 3kHz. We restricted the pass band to avoid any possibility of interference being created from noise, etc., coming from the *IC740* outside this passband from circuits after the SSB filter.

Hewlett Packard very kindly loaned me, for a short period, their complete new noise figure measurement system, worth around £8,000! We found to our great pleasure that preamps measured on both the R and S and HP systems gave readings within 0.1dB of each other which surprised me considerably, although we did not attempt to measure the very best preamps with the R and S system. The HP system employs a noise source which includes a noise diode and source impedance extremely accurately matched to 50 ohms from quite low frequencies up to many GHz. The noise head is designed to give out a level of 15.2dB excess noise over that which would be generated from a resistive source of 50 ohms, taking into account the temperature, etc. Noise is generated immediately upon a 28V DC source being switched through to the noise head. The measurement system switches this 28V on and off many times a second. The meter looks at the on and off noise values of the head when it is directly connected to the measurement system's input socket, which again is very carefully controlled at 50 ohms. The internal microprocessors were previously calibrated to expect a certain value of on to off noise, the calibration procedure being simple for the operator, but extremely complex for the microprocessor! Not only is the input noise figure of the measurement system calculated on calibration, but the frequency band over which the measurement is to be made can be pre-set on the instrument, together with the lower and upper limits of frequency at which measurements are to be taken. When you are calibrating, you must include all the adaptors, or those with equivalent loss, that you are going to use in the measurement loop, so that you are measuring only the device under test, and not the additional attenuation of a heap of adaptors! On placing the device in the loop, you can then get an immediate readout of noise figure and gain around the frequency of measurement. There are three very serious snags though, with using the HP gear, which absolutely must be taken into account: since the machine without ancillary mixers, etc. measures from 10-1,500MHz and with a bandwidth of around 4MHz, the internal local oscillator must be capable of avoiding image problems, and so the IF within the instrument is way above 1500MHz, and the yig oscillator is above this. These microwave oscillators are notoriously wibbly-wobbly, and the Hewlett Packard spec is fairly wide on the tuned-in input frequency, therefore. This in effect means that you must not accept the indicated tuned frequency as precise, especially at UHF, let alone microwave, unless you are measuring a wide bandwidth preamplifier. To get over this problem, you have to ascertain, by experimental means, the centre of the input passband of the measurement equipment. In fact, we never found the HP to be significantly out on VHF, although by 1296MHz it was quite a long way out. A more serious problem is that of the measurement bandwidth, for it measures the average noise fiture over a 4MHz bandwidth, as well as the total power gain over the same bandwidth. The only way of getting around this problem is to recalibrate with a much narrower filter immediately before the HP. For this, we used in many of our experiments, our Boonton tuneable preamplifier type *230A*, which has a 700kHz equivalent noise power bandwidth. I also had to use a 20dB attenuator immediately after it to get rid of some gain! By calibrating with

Wood and Douglas 144PA3 Miniature preamplier