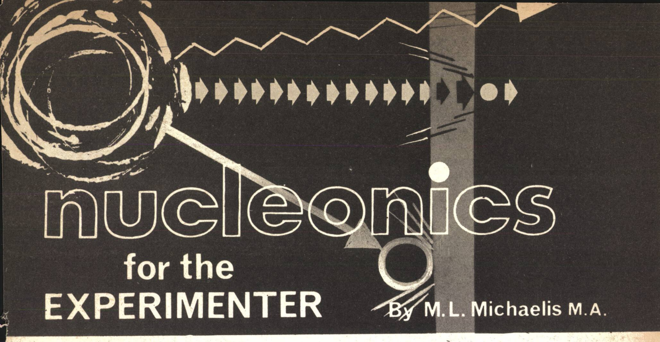


nucleonics for the EXPERIMENTER

By M. L. Michaelis M.A.

10—PROGRAMME CONTROL CIRCUIT; OPERATING STRACE

A WELL-DESIGNED programme control circuit should not lead to unnecessary increase of the number of manual controls. This rule is rigidly applied in the STRACE design.

Thus the reset contacts are combined with the chart recorder on/off switch, so that programme control is reset to the start of a sequence quite automatically when the chart recorder is first set running. Again, the e.h.t. supply for the G.M. counter detectors is not required when the scintillation detector and spectrometer is in operation, so extra contacts are used on the spectrometer mains switch on the front panel of the radiation meter, in order that G.M. counter e.h.t. is switched-on only when the scintillation detector is switched off, and vice versa. Furthermore, the programme logic circuit card is required only for spectroscopy with the scintillation detector; for work with the G.M. counter detectors, the 50 second master timebase is used alone (as explained below), and so both these switching functions are combined with the spectrometer on/off switch. In this manner, the programme control section as shown in Fig. 10.1 actually leads to no additional manual controls, apart from the mode switch, S4.

AUTOMATIC INTERLOCK

More complicated professional equipments often do have some additional manual controls solely for the programme functions, especially if mechanical devices for automatically changing samples at predetermined intervals, or according to measured activities, are to be included. Nevertheless, a good nucleonic equipment design is always characterised by maximum possible automatic interlock with the already existing controls for the basic functions.

We already met an example of this principle in the ratemeter sections of STRACE. Here we effected the range switching in such a manner as to preserve the design statistical accuracy for all ranges, instead of providing separate controls for range and statistical accuracy.

SPECTRUM COORDINATION

Nevertheless, some attention is required to the question of allowing sufficient time for the correct meter reading to be established. If the integration time (product of integrating capacitor and discharge resistor in the ratemeter) is t seconds, then at least $2t$ seconds of recording are needed before the reading has risen close enough to its final value for practical purposes.

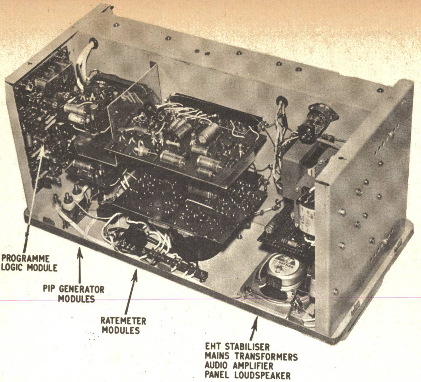
The scanner of the kick-sorter amplifier in the scintillation spectrometer must therefore be left operating for a sufficient time in each step. If we choose this "step time" to be of adequate length in relation to the lowest ratemeter range which possesses the longest integration time, then the same "step time" is more than ample for all other ranges.

In the STRACE equipment, the integration time for the 100 c.p.m. range is 160 seconds, so that the reading is sensibly established after 400 seconds, which period has thus been chosen as the spectrometer step time. We saw that the programme logic circuit derives the 400 second intervals by scaling-down the 50 second master timebase by a factor of eight, using three binary counter stages. The differential output of the kick-sorter amplifier is fed to channel 1 of the radiation meter, and the integral top output to channel 2. Each channel is recorded for 400 seconds before the scanner is moved to the next one of the 12 spectrum steps. The scanner is thus fed with a shift pulse only once every 800 seconds. We saw that this interval is derived in the programme logic circuit by counting-down from the 400-second intervals by a further factor of two, using a fourth binary counter stage.

Now the differential output of the spectrometer encompasses only a narrow range of detector pulse amplitudes, so that the counting rate may well be small on many occasions, requiring the 100 c.p.m. range. We saw that the reading here takes some 400 seconds to be established, so that a streak instead of a clean spot would be recorded on the chart, if the differential channel (channel 1) were to be recorded first of all in each 800 second scanner period. On the other hand, the integral top output of the spectrometer covers a larger pulse amplitude range and thus gives higher counting rates. The 100 c.p.m. range is here seldom if ever required, the 1,000 c.p.m. one normally being the lowest. This has an integration time of only 40 seconds, so that the reading is already established for most of a 400 second recording period.

Thus there is no objection to recording the integral top channel (channel 2) first of all in each 800 second scanner period. Consequently, the programme logic circuit ensures that the channel relay is set to channel 2 for the first 400 seconds, and to channel 1 for the last 400 seconds —not vice versa—of each 800 second period during which the scanner remains in the same spectrum step.

This type of spectrum coordination, at least as far as the principles are concerned, is quite typical of sequential analogue spectrometer systems in general.



STRACE Radiation Meter looking into the top of the chassis

Having understood the basic functions of the programme control section and why these are required, we may now consider the details of the actual circuit for STRACE, shown in Fig. 10.1.

WORKING WITH G.M. COUNTERS

The spectrometer switch S4 will be set to "OFF" for working with the G.M. counter detectors. Contact 1 of S4 then completes the a.c. input to the internal e.h.t. circuit for the G.M. counter tubes, whilst contact 2 switches the 50 second output from contact 1 of the master timebase relay RLC straight through to wafer S5A of the mode switch S5. Mains input for the scintillation detector spectrometer unit and for the programme logic subsidiary power pack is broken at contact 3 of S4. Provided the mode switch S5 is set to position 2 or 4, the pulse switch RLE receives a brief pulse of current from the timebase relay RLC once every 50 seconds.

The contact of the pulse switch RLE closes and opens on alternate current pulses, so that the channel relay RLD is alternatively energised and de-energised for 50 second periods. With the mode switch S5 in positions 2 or 4, the channel relay RLD thus connects channel 1 and channel 2 ratemeter outputs alternately through to the meter and chart recorder, for periods of 50 seconds. Channel 1 is always connected to the meter and recorder when the RLD is energised, and channel 2 when it is de-energised.

RECORDING MODES

In position 4 of the mode switch S5, no d.c. backing voltage is fed to the meter and recorder, so that the electrical zero points for both channels lie at scale zero. In position 2 of the mode switch S5, an adjustable (preset) stabilised backing voltage from VR1 is added in series with channel 2 only. The electrical zero for channel 1 is thus still at scale zero, but the electrical zero for channel 2 is then at 40 per cent or 50 per cent scale deflection, according to the setting of VR1. Forty per cent is convenient. The recordings for the two channels are then definitely separated on the chart paper, but a smaller width is available for each channel.

Whether the separated or the coincident mode is more convenient, will depend upon the ranges and relative counting rates involved in a given experiment. The aim is always to avoid confusion between the two simultaneous recordings which would result from unintelligible intersections in the wrong mode.

In position 3 of the mode switch S5, the channel switching pulses may be derived from any external timebase, instead of from the built-in master timebase. This is necessary when coordinating with other equipments.

The remaining two positions, 1 and 5, of the mode switch S5 respectively switch-through channel 1 or channel 2 *permanently* to the meter and chart recorder. This is useful for quick read-offs to select suitable ranges before starting a twin recording run, and for numerous other purposes. It satisfies the essential need to be able to read-off either channel at will without disturbing the two ratemeters and without having to wait for a corresponding timebase step.

PAPER FEED SPEED

The paper feed speed found to be most suitable for the "Multiscript 3" chart recorder for all types of work is 20mm/hour. The paper movement during each 50 second timebase period is then barely visible, so that the two traces for the respective channels appear essentially continuous, with no visible breaks. Yet the area between the two traces remains clear, because the recording is made by jerking the knife-edge pointer against the pressure sensitive paper only once every 2 seconds, with the help of the synchronous cam-driven stirrup of the recorder unit. Even at the channel switch-over points, the pointer thus has ample time to move to the other trace without striking the paper on the way.

A conventional pen-recorder would black-out the entire paper area between the two traces on moving back and forth between the channels, unless pen-lifting complications synchronised to the master timebase were introduced. The dropping-stirrup type of recorder is thus much more suitable for twin-channel recording with a single-channel unit. The *Metrawatt "Multiscript 3"* recorder is obtainable from Messrs. Smiths Electric Clocks Ltd. It is also much cheaper than a conventional pen recorder, and quite free from ink dry-out and similar troubles.

WORKING WITH THE SCINTILLATION SPECTROMETER

When the spectrometer on/off switch S4 is switched on, contact 3 feeds the mains voltage to the scintillation spectrometer unit and to the mains transformer T1 of the programme logic subsidiary power supply, so that all these circuits can now operate. At the same time, contacts 1 and 2 of S4 are broken, so that the G.M. counter e.h.t. circuit is

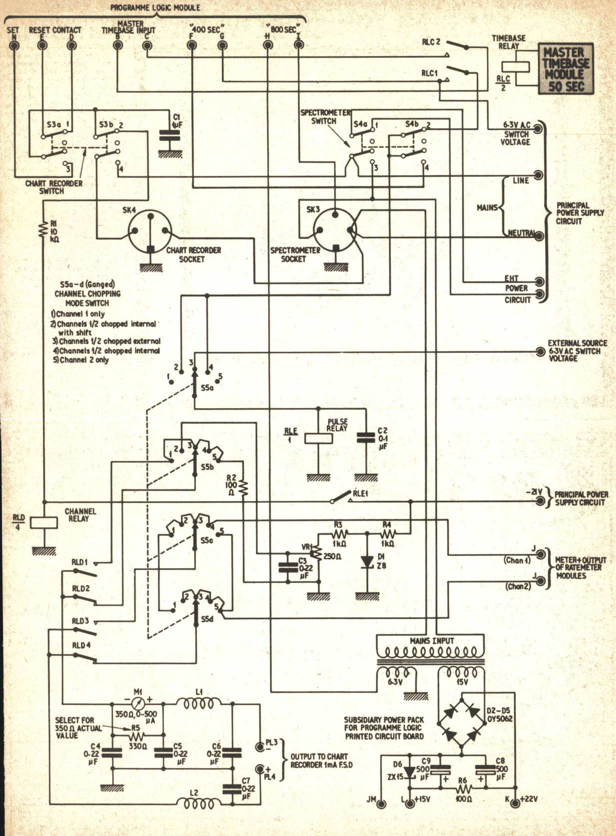
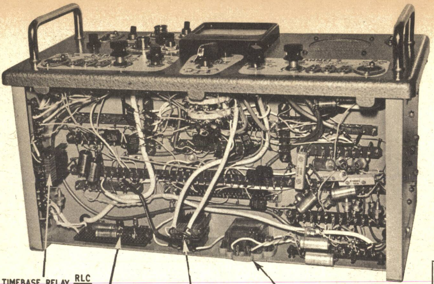


Fig. 10.1. **STRACE RADIATION METER:** *circuit diagram of the programme control*



STRACE Radiation Meter, under sideview

> **CORRECTION**
>
> **Fig. 9.2**
>
> **C5, C9 should be 1nF (=1,000pF) each**

switched off and the direct 50 second interval feed from the master timebase to the pulse switch is broken. Instead, contact 4 of the spectrometer switch S4 now feeds the 400 second output pulses from the programme logic to the pulse switch RLE, via the mode switch S5. The function of the mode switch has not been changed in any way.

The 50 second master timebase pulses are now fed from contact 2 of the timebase relay RLC, as input to the programme logic circuit for counting-down. But as long as the chart recorder switch S3 is still off, the programme logic can not respond to the master timebase, because contact 1 of S1 holds the binary stages fast in the zero state. At the same time, contact 2 of S3 holds C1 charged to −21V via R1, if the channel relay RLD is energised, i.e. if the meter and recorder are connected to channel 1.

Now comes the moment when all is ready, and the chart recorder motor switch S3 is switched on. Contact 1 opens, and the programme logic can then commence to count-down the master timebase pulses. If and only if C1 was charged, the set line N receives a negative pulse via contact 3 of S3 and causes a 400 second pulse to appear at once from the programme logic, throwing the meter and recorder onto channel 2, for the reasons already explained above. Contact 4 of S3 connects the mains voltage to the chart recorder motor.

At the recommended paper feed speed of 20mm/hour, each 400 second interval corresponds to about 2mm paper movement. The statistical fluctuations of the trace also amount to roughly 2mm trace width. Thus each spectrum point appears as a black blob about 2mm in diameter on the chart. The centre-point can easily be assessed by the eye, as the true mean reading. The sequence of successive blobs for each spectrum trace is spaced with 2mm gaps, corresponding to the blobs of the other trace. The 12 points of each spectrum run are thus clearly resolved, and the integral top for each spectrum step falls against the gap *preceding* the differential blob, since we have already explained that the integral top must be recorded for the first, and the differential for the second 400 seconds of each 800 second step.

CONTINUOUS RECORDINGS

If it is desired to make continuous recordings for particular energy levels, instead of scanning complete spectra, then the scintillation spectrometer mode switch must be set to the "SIM" mode, the limit potentiometers set to the energy limits of interest, and the mode switch S5 on the radiation meter unit set to position 1 "channel 1 continuous". A single continuous recording is then traced for the differential channel, e.g. to study the rate of increase or decay of the sample activity in the tuned-in energy range. The programme logic is running, but without effect, in this setting.

INTERFERENCE SUPPRESSION

The chokes L1, L2 and capacitors C6, C7 in Fig. 10.1 prevent the entry of r.f. interference picked-up by the chart recorder cable. Strong shortwave broadcast transmitters could cause trouble without the suppressor components, so that they should always be included.

The chokes and capacitors behind the principal mains input socket (see Fig. 8.3) serve the same purpose for the mains cable. A fully enclosed metal cabinet is essential for all units. All pulse cables must be coaxial, but mains and recorder current cables may be ordinary unscreened types. The r.f. chokes each consist of a single layer of about 100 turns of 30 s.w.g. enamelled copper wire wound onto a long 2·2 megohm 2W carbon resistor, with the wire ends soldered tightly to the resistor leads.

The correlation between the channels and the 400 second pulses is thrown into the correct phase only at the moment when the chart recorder motor switch S3 (Fig. 10.1) is switched-on. If the logic were to get out of step at some later time, self-correction is impossible. High counting stability is thus demanded for the count-down system in the programme logic circuit. This is achieved by ample threshold margins in the binary stages used, driver stages between successive binary stages and the Schmitt trigger at the input to the programme logic, which prevents multiple responses to contact rebounds of the timebase relay.

The circuit has in practice never got out of step during many weeks of continuous running, except just once when somebody accidentally turned off a mains master switch, and on again at once upon seeing all pilot lamps extinguish!

Such disturbances of course make any computer forget what it has calculated so far, so it is no reproach when the programme thereby gets out of step.

This concludes the present series in which we have surveyed nucleonic equipment in general, and have described in some detail a comprehensive equipment suitable for amateur construction. Schools and colleges will find this equipment valuable for teaching purposes as well as for pure research.

In order that the possibilities of STRACE may be fully exploited, it is proposed to commence in a few months time a short series of articles describing practical experiments using this equipment. In the meanwhile comments are invited from those who have been following the present series of articles.

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