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THE CPS TARGET SYSTEM

1. INTRODUCTION.

Starting in Autumn 1959, the initial development of the present CPS target system coincided partly with the early coming into operation of the Proton Synchrotron. The resulting pressure was particularly strong during the first half of 1960, when only limited effort was available since the Machine Group was just being built up. Though temporary solutions had to be adopted at some stages, from the outset an effort was made to devise a system which would allow one to incorporate future growth and improvements without too drastic changes or interruptions of the target operation.

For the design, little direct benefit could be derived from experience gained elsewhere. Either the existing targets were much heavier, as in the weak focusing machines [1),2),3)] or the cycling rate was much higher, as in the case of the strong focusing electron synchrotron at Cornell [4)]. The references quoted conveyed however a good impression of more general problems of target design and operation.

The target development is continuing and will do so for some time to come. The reason for reporting on the early development up to about June 1960 at this stage is not only that the writer has now left this work but also that sufficient experience has been gained to permit a discussion of the advantages and drawbacks of various solutions.

The main points covered are the systems design aspect and the description of the parts which belong to the present operating system as opposed to parts which have been replaced in the meantime by more final versions. Some results of the observations and measurements made on the interaction between the targets and the circulating proton beam have already been reported [5),6)].

The report is subdivided as follows :

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2. REQUIREMENTS.

The general target situation has been discussed at an early stage of the CPS design [7),8)]. About a dozen targets distributed along the South Target Area were foreseen for production of all types of beams, at angles varying from 0° to about 350°.

Later it was envisaged to use double targets as limiting apertures for beam studies. They were to be brought rapidly into working position at any time during the accelerating cycle, a task which the apertures normally used, the flags, could not fulfill because of their slow speed. It was thought desirable to mount these double targets anywhere around the machine.

This situation lead to the first requirement for the design of the target system. The general purpose targets had to be of such a type that they could be mounted into and operated in any straight section of the machine. This meant that they would go into one of the small boxes which form part of the vacuum chamber in the coil overhang region of a magnet unit.

The implication for the cable connections was the need to create a flexible system with many terminal boxes in the Ring, a sufficient number of leads to the target control racks in the Main Control Room and a junction box in between for connecting the two types of runs in the required manner.

Furthermore the requirements on points of detail listed in Table I were established, partly through discussions with the physicists.

Table I : REQUIREMENTS FOR CPS TARGETS

Part of the system	Function	Required performance
Target mechanism	In-out motion of target head	Moving heads of about 10 g weight in about 20 ms
	Changing radial position of head	Speed about 1 mm/s; remote control

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Part of the system	Function	Required performance
Target controls	Timing of in-out motion	Reproduceable triggering (jitter < 10 μs) during entire magnet cycle, possibility to lock with magnetic field
	Duration of stay of head in the "in" position	Times from less than 1 ms to about 1 s
	Speed of in-out motion	Variable by a factor of the order of 5
	Radial position of the target head	Positioning to about $\pm$ 0,5 mm
Target indications	In-out motion of target head	Minimum : Indication of final position by signal lamps Ideally : Continuous indication of position
	Radial position	Indication to about $\pm$ 0,5 mm
	Secondary burst	Indication of shape and occurrence in time.

3. DESIGN CONSIDERATIONS.

3.1 Mechanical system.

3.1.1 Types of motion.

During the early stages of the acceleration, the full cross-section of the vacuum chamber (14,5 cm wide by 7 cm high) is required for accomodating the proton beam. The target head must therefore stay outside this area until the beam diameter has shrunk sufficiently. This means for the motion of the target head that it must cover a distance of the order of 10 cm. The solution adopted is shown in Fig. 1 to 4. The considerations leading to this solution are summarized in Table II.

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Table II : COMPARISON OF 4 TYPES OF IN-OUT MOTION (Fig. 5)

Type of motion	Advantages	Drawbacks
Vertical motion	A. Small displacement of head B. Radial position can be changed independently C. Head can be rotated in horizontal plane without affecting in-out motion D. No obstruction in horizontal plane	a) Vacuum seal for rapid to and fro motions required b) Vertical dimensions larger than space available inside magnet units
Radial motion	E. Can be placed anywhere on the 628 m circumference of the CPS F. Horizontal wire targets can be brought into working position without inducing considerable mechanical oscillations	Lacking A., B., C. and D. while sharing a)
Rotating motion in cross-sectional plane (around axis parallel to tangent on beam)	G. Head may stay in beam for a very short time only H. In-out motion may take place completely inside the vacuum. A., B., C., D. may be maintained, at least partly without necessarily loosing E.	Absence of F.
Rotating motion in the vertical plane (around axis parallel to the radial direction)	I. Driving element can be placed at a conveniently large distance from the target head without necessarily breaking the vacuum. A., B., D. and E. can be maintained.	Absence of C., F. and G.

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As these considerations show clearly the advantages of the rotating motion around an axis parallel to the tangent onto the proton orbit, this type of motion was adopted for the first CPS targets.

3.1.2 Choice of driving force.

The sources of driving force considered are discussed in Table III.

Table III : TYPES OF DRIVING FORCE

Nature of force	Advantages	Drawbacks
Gravity	Reliability, omnipresence, cheapness	Fixed direction and strength (This does not exclude the utilization of gravity for driving special targets [9])
Mechanical springs	Reliable for millions of working cycles. Force can be calculated and designed to suit almost any requirement	Must be rearmed after every action. Available force lessens with progress of action
Electromagnets (To and fro or rotating motion)	Comparatively small dimensions and high forces. Convenient, reliable and rapid control	Restricted length of stroke (about 1 cm in the small magnets considered here). Saturation of steel yoke limits force
Rotating motors	Possibility of storing larger forces	Timing of their utilization depends on precise working of clutch which couples motor to the axis to be rotated
Compressed air (moving piston back and forth)	Long stroke. Shape of displacement vs time curve for forward and backward motion can be changed in wide limits. Greater forces can be obtained than from the forces listed above	Use inside vacuum is inconvenient. Less readily available than e.g. an electric current

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Nature of force	Advantages	Drawbacks
Hydraulic systems	As for compressed air; forces still larger	As for compressed air; installation of supply as much work as target.
Explosives	Production of short low intensity secondary beams through interaction of collimated gas jet crossing beam with a speed of more than 10 000 m/s.	Reloading (1200 times/h). Possibly operational costs

As a result of the foregoing considerations, an electromagnet was chosen as source of the driving force for the first CPS targets.

3.2 Electrical system.

3.2.1 Motion of target head.

The requirements for the control of the in-out motion have been listed in Section 2. The problem was essentially to provide a corresponding current pulse of about 2 A peak for powering the actuating magnet.

The basic decisions which had to be taken included the choice of the current gate, of the type of trigger pulses to be used and the distribution in space of the various parts.

A comparison of the considered components for the current gate is given in Table IV.

Table IV : COMPARISON OF COMPONENTS FOR CURRENT GATE

Type of components	Advantages	Drawbacks
Electromechanical relays	Simplicity, reliability (if protected properly)	Slowness. Wear of contacts for currents of a few amperes

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Type of components	Advantages	Drawbacks
Power tubes	Switching speed	Take up much space. Need bulky power supplies
Cold cathode tubes	Switching speed	Not always reliable. Must be triggered on and off independently
Power transistor	Small size. Easy control. Supply voltages admitted for PS control cable system.	Very limited experience available in the Laboratory

In view of the advantages listed, power transistors were chosen for controlling the energizing current of the target actuating magnets. A monostable multivibrator transistorized circuit was developed for steering the power transistor.

As to the trigger pulses, the only usable ones directly available at the time were either the standard machine pulses delayed by a double pulse generator or the B 10 - pulses counted by an Etelco timing unit. (It is not proposed to explain here the various CPS timing systems. For an introduction and references cp. e.g. [10),11)]). Such a unit (delivering a single pulse) takes up a height of 6 units in panel space and costs about Sw.Fr. 3.000.--. It was therefore thought worth while to develop a simpler type of timing unit. The resulting apparatus, described in 4.3.2 provides 12 independent timing signals at the expense of 10 units of panel space in height and a total cost of about Sw.Fr. 2.500.--.

For the exclusive triggering of the transistorized target drive units it would have been sufficient to provide trigger pulses of a few volts. In view of their more general use, the timing units were however fitted with blocking oscillators for producing standard pulses.

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In considering the distribution in space of the various parts of the apparatus, the following points were of particular importance. In order to avoid a large voltage drop along the cable connection between the target controls in the Main Control Room and the target in the Ring, one can essentially either place the power transistor close to the target or make the cable of sufficiently low impedance. An experimental version of a power stage for use close to the target was used for some time, however this solution was abandoned. The reasons for this were mainly that in case of failure any check required a break of machine operation and a time consuming expedition into the Ring, and also the danger of radiation damage.

It would in principle have been possible to house the controls for the target trigger, the speed of the head and the duration of its stay in the in-position all in the same chassis. In view of the uncertainty concerning the timing system to be used finally, it was thought desirable however to keep the trigger controls apart. The trigger pulse could then also be used conveniently for steering an automatic programmed target operation.

As an outcome of these considerations, the final system consists of the self-contained chassis with two drive channels to be described in 4.3.3, an independent trigger system for these channels and a low impedance $(3\,\Omega)$ cable connection to the target actuating magnet.

3.2.2 Indication of motion.

The most desirable indication is one which allows one to determine at any moment the precise position of the target head. For the rotating motion adopted, such a continuous indication can be provided e.g. by an optical arrangement or by a rotating condenser which forms part of an a.c. bridge circuit.

In view of the need to have available rapidly some kind of reliable information, it was however not thought wise to embark upon such a relatively ambitious project. Simple microswitches were developed instead for indicating the out or in position itself. They also allow a measurement of the total time needed for the in-out motion.

3.2.3 Change of radial target position.

Here the choice was essentially between a simple directly controlled electric motor with a potentiometer arrangement for the position indication and a servo controlled unit with a selsyn or similar type of control. The latter solution permits one to obtain a much larger range of driving speeds and provides an easy control of precision settings (i.e. tenths of millimeters). In view of the lesser complication, the direct control of the motor was however chosen for a start, the more refined solution remaining envisaged for later, when the demands on the precision of the positioning were expected to become more stringent.

4. THE STANDARD TARGET SYSTEM.

4.1 Introduction.

The standard target system consists of a larger number of target units placed in the machine (Fig. 1, 2 and 3), the control racks in the Main Control Room (Fig. 6) and the special target cable network for connecting both.

The target units can be placed into any of the small boxes forming part of the vacuum system in the coil overhang region (Fig. 2), or they can be mounted in a free straight section, either horizontally or vertically. In the latter case, some modification to the vacuum chamber is required. Each unit contains normally 2 target heads which can be flipped into the beam independently.

In the initial installation, 12 complete control channels have been foreseen, allowing the simultaneous use of up to 12 target heads during one run. Room for extensions has been reserved.

All controls and the information necessary for running the targets have been grouped together for easy operation. The right hand rack (Fig. 6) contains essentially the chassis for the production of the trigger pulses and their programming, the left hand rack houses the 6 target drive

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units and the radial position controls whereas a 555 C.R.O. has been placed in the centre rack for the necessary observations. A 4-channel scope input selector allows one to display any of several signals interesting for target operation, the 555 scope permitting to observe simultaneously its gross and fine structure.

4.2 Target units.

An experimental unit of high speed apertures had been designed by the PS Drawing Office at the suggestion of M.G.N. Hine when the writer took up the work on targets. This unit was then developed into the present target units by adding the microswitches and the vacuum tight connectors, and by replacing the link between the actuating magnet and the rotating axis which carries the target head, by a type with a longer life. Furthermore the method of fixing the target heads on the axis was changed to facilitate their exchange without loss of precision in the positioning.

Though already reliable and very useful, these units have been developed further in the meantime and it seems therefore of little value to describe here in detail an intermediate stage. Some performance data may however be of interest, as they will probably not be much affected by the current developments.

The total time required for bringing a normal target head (of 2 to 5 g weight) into the beam is of the order of 20 ms, the shortest stay up time about 10 ms and the time for bringing the head back to the rest position about 40 ms. A head of a few grammes weight enters the beam with a speed of about 0,5 mm/ms.

4.3 Electrical system.

4.3.1 Introduction.

The simplified block diagram for one channel of the electrical system is shown in Fig. 7. All the electronic apparatus, viz. controls, indications and power supplies are located in the target control

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racks in the Main Control Room (Fig. 6). For both the in-out motion of the head and the target positioning, the controls and indications are contained in the same unit, though for clarity they are shown separately in Fig. 7. A direct cable run connects these units to the Ring Junction Box located in the Target Area. In this box a jumper connects the run through to one of the 11 terminal boxes on the Magnet Units. From there 2 cables connect up the actuating magnet for the in-out motion as well as the microswitch for the indication of this motion, and the d.c. motor for the target positioning and the potentiometer for the corresponding indication.

4.3.2 Target timing unit.

The circuit diagram of one of the twelve channels of the target timing unit is shown in Fig. 8 and the front panel in Fig. 6. Each channel consists essentially of 4 decade selectors and a fourfold coincidence circuit, which gates the bias of the blocking oscillator.

When the four selected B 10 pulses (which are produced by the four scalers in the lens and p.f.w. control rack) have cut off the diodes OA 202, the NT 2 is fired and in turn the grid potential of the blocking oscillator is raised. The next B 10 pulse can then trigger the oscillator and the selected timing pulse is produced.

As will be apparent from this description, the settings of the target timing unit must be 1 unit lower than the setting of a standard Etelco unit if both apparatus are to produce the same pulse. This small inconvenience was thought acceptable in view of the gain in simplicity, compactness and cost. Above all, the present design allows one to produce standard timing pulses with the target timing unit which intrinsically do not exhibit any significant jitter with respect to the pulses produced by an Etelco unit.

The timing unit described may be run equally well with M-pulses (instead of B 10 pulses) provided the output pulses from the corresponding 4 decade scaler are available.

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4.3.3 Target drive unit.

The circuit diagram of a target drive unit is shown in Fig. 9 and the front panel in Fig. 6.

After the triggering action, the monostable multivibrator is switched back to the stable state either as a consequence of the discharge of the condenser C or by a second trigger signal applied to the STOP input. Thus a current pulse can be produced either of a preset duration (5, 10, 25, 50, 75, 100, 150, 200, 250 or about 1300 ms) or of a variable length, controlled by the arrival of the stop pulse.

After amplification in the drive and output stages, this current pulse is suitable for driving the actuating magnet for the in-out motion of the target head. The potentiometer labelled ACCELERATION controls the voltage on the actuating magnet and hence the acceleration of the target head. Provision has been made for inserting in series with this potentiometer a resistor which is fixed to the target unit itself. This is necessary when extra thin foil targets are used, which would otherwise get mechanically damaged when highest acceleration is used.

As to the voltage to be applied to the actuating magnet, two conflicting requirements had to be satisfied. A high voltage is required in order to get a large acceleration. A low voltage is wanted in order to keep the dissipation in the magnet low. Both requirements are met by applying initially the full voltage (55 V) from the 250 μF condenser to a magnet rated for 24 V operation. On decharging the condenser, the voltage is lowered until it is caught at a level which is given by the potential divider consisting of the resistance of the 0,5 A STOP fuse ($\sim 10\ \Omega$), the line impedance ($\sim 3\ \Omega$) and the resistance of the magnet ($\sim 14\ \Omega$), assuming the potentiometer short-circuited. This arrangement has made it possible to complete the target in-motion of light heads in about 15 ms and to obtain simultaneously stay-up times of 500 ms, corresponding to a 10 o/o duty cycle of the magnet (in vacuum), whereas the rating is only for a 5 o/o duty cycle (in air).

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The target in-out position is indicated by the lamps and registered by a Sodeco counter as indicated in Fig. 9. It can also be displayed on the C.R.O. as shown in Fig. 4. Provision has been made to indicate the target in-out motion also on the experimental target programme selector to be discussed below.

4.3.4 Target programme selector.

At an early date, the need for programmed target operation was recognized. Almost nothing was known, however, about the exact functions to be programmed, nor about the detailed programmes. As a guess, it was assumed that the two main types of programmes wanted were on the one hand a programme for sharing the beam between two targets (i.e. X pulses on target A and Y pulses on target B) and on the other hand a programme for cloud chamber operation, the repetition rate of which is known to be of the order of minutes as compared to the order of seconds for the cycling rate.

On these assumptions, an experimental 12 channel programme selector has been designed and constructed (Fig. 6). It has been used successfully for both beam sharing and target operation for cloud chamber work.

As explained elsewhere [12] more functions need now to be programmed than the target trigger. A new programme unit is therefore being designed in which the relays of the present unit are replaced by a complete matrix system. In view of this new development, only the self-explanatory circuit diagram of existing apparatus is reproduced in Fig. 10.

4.3.5 Controls for target positioning.

Normal 24 V d.c. motors are used for controlling the target position by means of a rack and pinion drive. The position is measured by means of a standard potentiometer arrangement, though for higher precision a bridge circuit is now employed for indicating the position. The interesting data are given in Fig. 11.

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4.4 Target cable system.

The general layout of the target cable system is shown in Fig. 7 and the detailed connections for one channel in Fig. 11.

The system was largely determined by the plugs and sockets employed for the jumpers in the Ring Junction Box. The higher the number of cores in this jumper, the more connections can be changed in a single operation. However there is a limit when the jumper becomes inconveniently stiff and heavy. As 11 cores were required for a channel of the proposed first installation, 14 core jumpers were chosen as an acceptable compromise. With the 14th core used for the earth connection, 2 spare cores were available in this way, allowing a small addition to the target controls and indications.

Any further extension of these controls (e.g. servo controlled target positioning) was expected to require an additional cable run. In view of this and the anticipated needs of other prospective users (e.g. ejection equipment), a higher number of runs was foreseen between the terminal boxes on the magnet units and the Ring Junction Box, also because these cables take much time to be installed. The 12 runs from the Ring Junction Box to the Main Control Room can be augmented easily by 12 further runs, for which room is already foreseen.

As to the types of cables used in a run (Fig. 11), they were determined by the requirements of the transmission characteristics and considerations of cost and convenience of installation. The use of the shield of the 2 core cables as a third core leaves the second 2 core as a complete spare.

The same type of boxes was used for the terminal boxes as has been previously used for the general control cables ending on the magnet units. The available space was used sparingly by putting cables and connectors in the bottom third of the box, leaving the rest free for further cable systems or electronic chassis associated with target operation. Part of this space has now been used for installing a cable network for target monitor counters.

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Further details of the target cable system are contained in the respective drawings of the Controls Section of the PS Machine Group.

101 - 53 - 1	Cable diagram of target network
103 - 343 - 0	Wiring diagram - Terminals in Main Control Room (MR 37)
103 - 129 - 4	Wiring diagram - 5 pin Tuchel plugs MR 37 - J...B
103 - 324 - 0	Wiring diagram - Terminals in Main Control Room MR 31 - MR 40 (see for HT and 75 Ω)
103 - 126 - 0	Wiring diagram of Ring Junction Box TJ 3 (2 sheets)
103 - 127 - 0	Wiring diagram of Ring Junction Box TJ 4 patch panel multicore cables
103 - 128 - 0	Wiring diagram of Ring Junction Box TJ 5 (2 sheets)
103 - 143 - 0	Wiring diagram of Ring Junction Box TJ 6 patch panel HT and 75 Ω
103 - 131 - 2 to 103 - 142 - 2	Wiring diagram - J...B (terminal boxes on the magnet units)
103 - 130 - 4	Wiring diagram - Connection of 12 pin Tuchel and 6 pin Lemo.

5. TARGET OPERATION.

5.1 Target heads.

Two types of target heads are shown in Fig. 3. Several variations of the self-supporting sheet or wire head have been tried out [5]. A 500 ms burst has been obtained using a 1 mm $^{\square}$ Al wire, mounted almost horizontally.

As there are problems of heat dissipation in thin foils (of about 10 μ thick at beam intensities of several 10^{11} protons/pulse), wire mesh and foil grid heads have been tried out. The latter were produced from full foils using a photographic etching method. The results were satisfactory except that these heads are unsuitable for point source targets.

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For facilitating the production of foil target heads, a die has been manufactured for stamping of a frame of the type shown in Fig. 3. Similarly the stock of appropriate materials listed in Table 1 has been built up for allowing rapid production of various types of heads.

Table 1 : Stock of target materials

Material	Foils, sheets (thickness in mm.)	Rods (preferably square cross section, dimensions in mm.)	
Beryllium	0,015 - 0,025 - 0,050 - 0,1 - 0,3 - 0,5 - 1 - 2 - 3	0,5 - 1 - 2 - 5	7 cm length
Aluminium, Stainless steel, Copper, Molybdenum	0,005 - 0,010 - 0,025 - 0,05 - 0,1 - 0,3 - 0,5 - 1 - 2 - 5 - 10 - 20	0,5 - 1 - 2 - 5 - 10 - 20	50 cm length
Tungsten		0,5 - 1 - 2 - 5	
Gold or Tantalum	0,005 - 0,01 - 0,025 - 0,05 - 0,1 - 0,3 - 0,5 - 1 - 2 - 5		
Polyethylen	0,005 - 0,01 - 0,025 - 0,05 - 0,1 - 0,2 - 0,5	0,5 - 1 - 2 - 5 - 10 - 20	50 cm length
For chemists	(99,999 o/o pure)		
- Aluminium	0,01		
- Copper	0,1 - 0,5		
- Iron	1		
- Cobalt	1		
- Uranium^{238}	1.		

5.2 Operational methods.

The main operational methods have already been described [13]. For counter experiments, the debunched beam is slowly steered onto a thin target by means of the main magnetic field, leading regularly to burst lengths of about 50 ms. For bubble chamber operation the beam can be steered quickly onto a

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thick target by means of a special magnet, the "R.F. knock-out", leading to reproducible bursts of a few hundred microsecond duration. If only a small fraction of the circulating beam is to interact in the target, the fast flipper attachment developed recently [14] can be used advantageously instead of the K.O. operated thick target [15].

5.3 Routine operation.

For the purpose of the routine operation of the targets, several conventions and designations had to be worked out to be used in the various instructions. Particularly useful proved a code system for target designation [16] which allows one to refer to any target in an unambiguous way.

6. CONCLUSIONS.

On the whole, the CPS target system as described in this report has given satisfactory service, i.e. the physicists have almost always had at their disposal beams of the required characteristics. In particular, the following solutions proved themselves in the course of several months of operation :

a) In the present version the mechanical target system including the home made micro-switches worked up to 2 million times in the laboratory without failure.

b) The fast though comparatively small actuating magnets worked reliably hundred thousand of times in vacuum and in outer magnetic fields of up to 0.2 Wb/m^2.

c) The provision of 12 independent channels throughout allowed operation of a sufficient number of targets during one machine run, including spare targets. In case of failure of a component, rapid change over to a standby channel was possible in most cases.

d) The flexible transistorized controls of the drive units fulfilled most requirements concerning the in-out motion of heads from less than 1 g to tenths of grammes weight.

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e) The physical separation of the timing controls proved valuable for experimenting independently on that parameter and for the programming of the target operation.

f) The installation of a special target cable network provided direct, low impedance connections largely free from interferences or interruptions.

Room for further development was found to exist particularly in connection with the following items :

g) The target positioning needs higher accuracy for the control as well as for the indications, once refined beam optics come into play such as in particle separators.

h) The production of short bursts by mechanical methods (e.g. fast flipper) could probably be extended over a wide range of secondary beam characteristics, always using the rest of the primary beam for counter experiments. Similarly a fast large foil target head would be useful for the measurement of absolute cross-sections. (The first attempt was not very successful because the large head was too slow).

i) For comparison of different heads and for rapid replacement of a broken head, it would be useful to have a target unit with several heads, which could be put into the same position by remote control. (As a preliminary solution, target units have been used, in which the two heads come up from the same side).

j) A target monitor system [17] is required for checking target operation and comparing different targets.

k) The programmed operation of targets [12],[17] can be elaborated considerably.

l) The timing controls may probably be simplified, once the CPS timing system is improved as planned at present.

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m) Techniques such as transistorization, plug-in cards, etc. could be applied to an even larger extent.

Developments on some of these points have progressed since, particularly on g), h), i) and j).

Finally it may be said that the target system described makes full use of some particular features of an A.G. machine such as the high momentum compaction. It has exploited light rapidly moving multitraversal heads and the small size of the vacuum chamber which made possible the production of beams of scattered out protons. Similarly the maximum available main magnet excitation power has been used for operating targets at constant machine energy for up to 500 ms.

7. ACKNOWLEDGEMENTS.

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The transistorized circuits were designed initially by G. Kuhn. Having received some thought from G. Amato and H.R. Haeubi, these circuits were further developed by B. Sagnell and A. Vaughan who developed also the timing units and the programme selector. H.R. Haeubi and R. Lüscher helped with the design of the target positioning and indication. All electronic components were built in the Electronic Workshop under B. Mary.

P. Collet and later Ch. Brooks contributed to the installation and the testing of the system.

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The vacuum testing was done by B. Monnier and the vacuum technicians, particularly A. Burlet. B. Monnier also built up the stock of target materials.

The details of the target cable system were designed by the Controls Section under G. Brianti. They also carried out the installation work which was supervised by J. Thorlund-Petersen.

Finally it is a pleasure to thank G. von Dardel, H. Fischer, J.A. Geibel, M.G.N. Hine, G.L. Munday and P.H. Standley for useful discussions.

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/SD

PS/2233

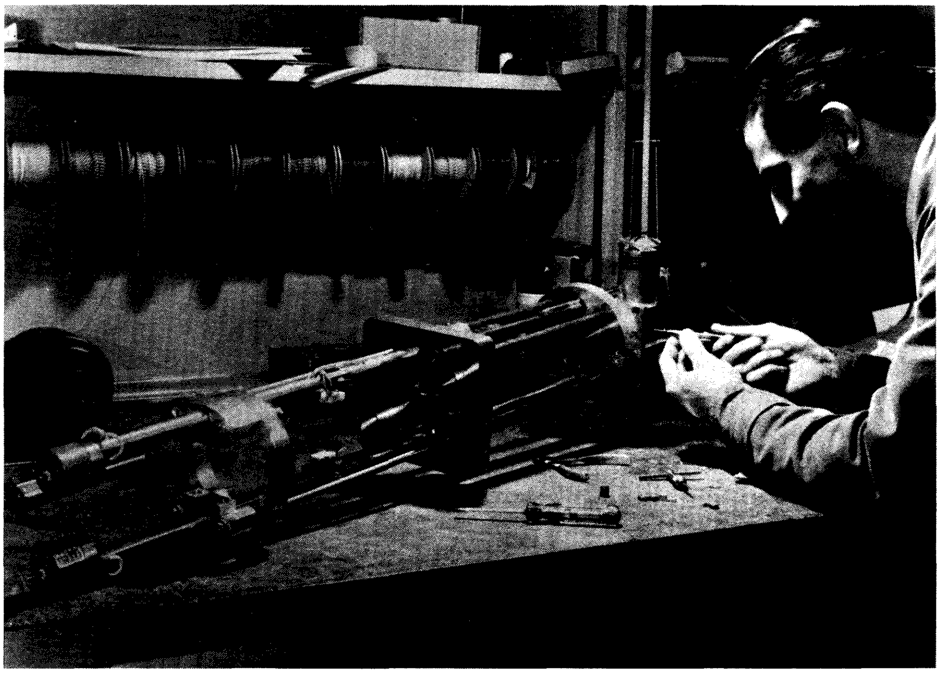


Fig. 1 Standard target unit showing from left to right the 2 electromagnetic actuators for flipping the target heads, the square flange for mounting the unit into the vacuum chamber and the motors for the remote control of the radial target position.

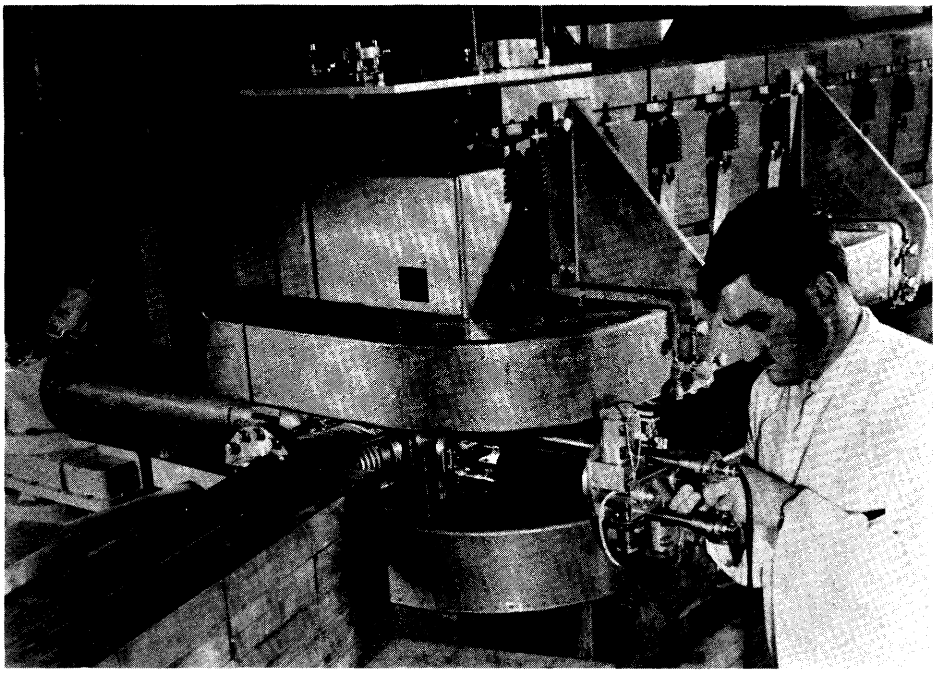


Fig. 2 Target unit mounted in standard position in magnet unit No. 5. Fróm right to left: vacuum tight socket and connector for actuator leads and target "in-out" signal, motors, gear boxes and potentiometers for control and indication of radial position, window (in flange) for observation of target motion.

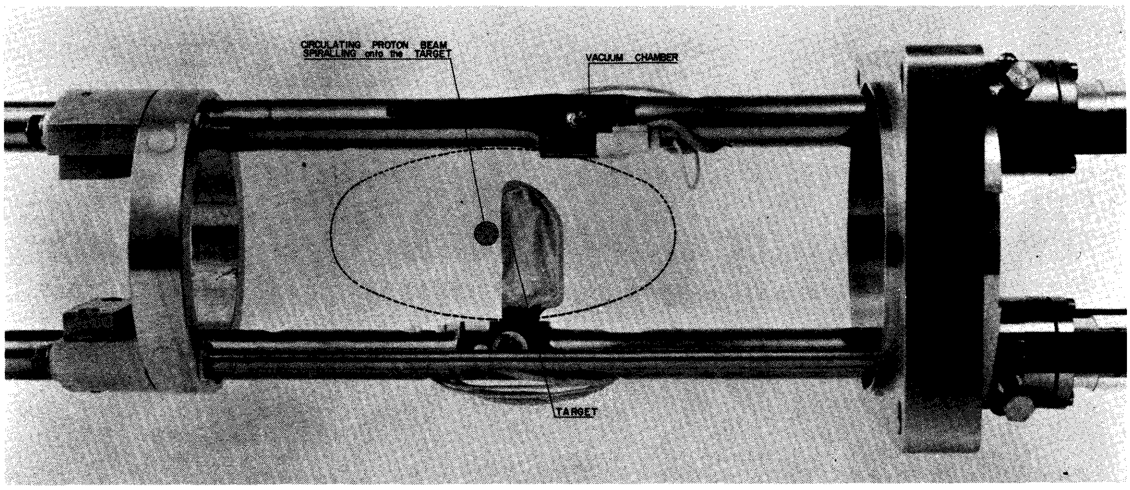


Fig. 3 Partial view of target unit showing lower target head of 0.01 mm aluminium in the "in" position, upper head of 0.2 mm aluminium in the "out" position. Note white microswitch, which indicates either of these positions. The indicated position of the vacuum chamber and the beam corresponds to the standard mounting of the target.

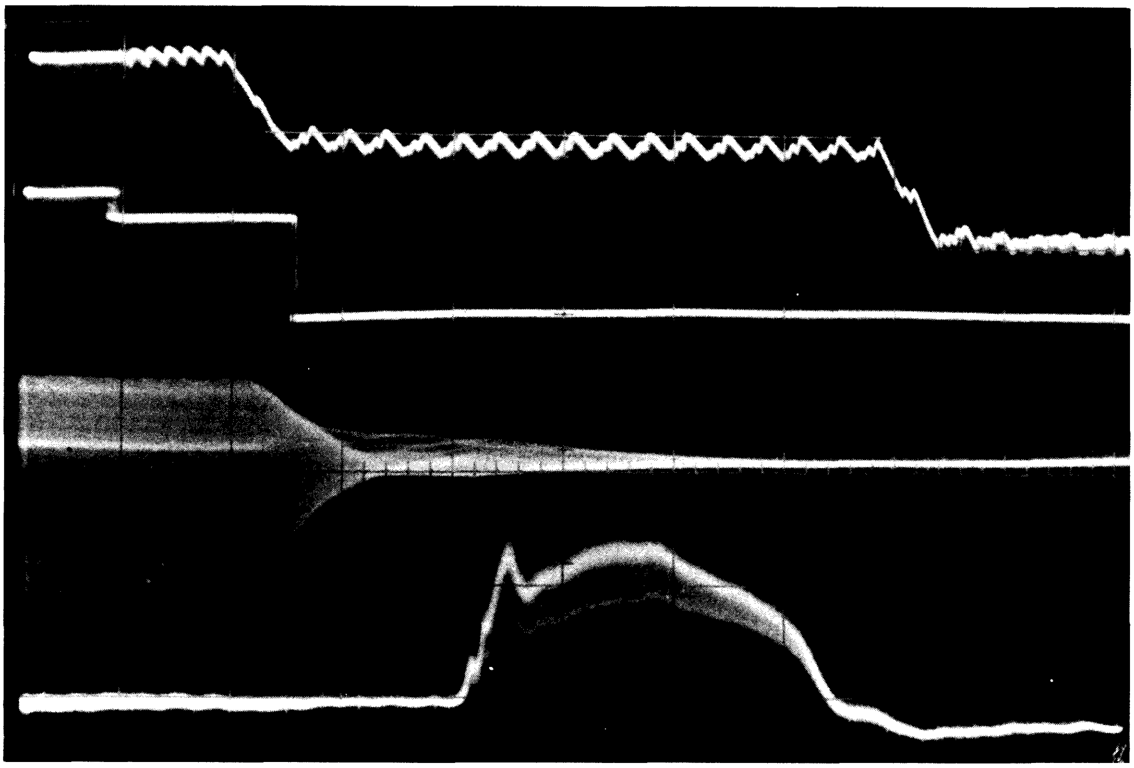


Fig. 4 Photograph of oscilloscope screen showing the four standard traces for "Flat-Top" target operation for counter experiments.

Uppermost trace	:	Magnet voltage.
Second trace	:	Target "in" signal.
Third trace	:	Intensity of bunched beam (beam is debunched by removing action of RF acceleration on reaching the "Flat-Top").
Fourth trace	:	Signal from scintillation counter looking at target. The burst of about 30 ms duration starts when spiralling out beam reaches the target, ends when beam has interacted in target or has been scattered out of the vacuum chamber.

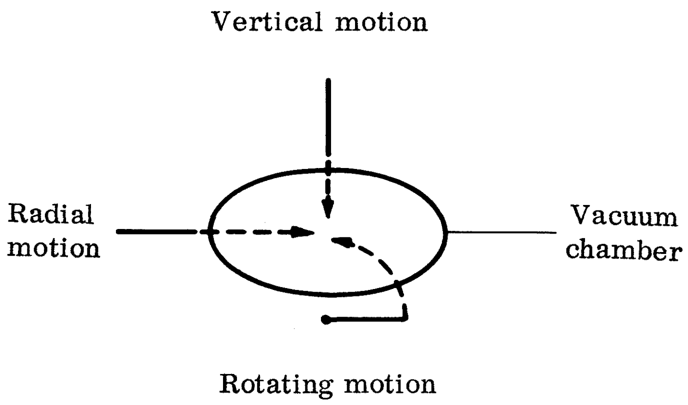


Fig. 5

TYPES OF MOTION OF TARGET HEAD

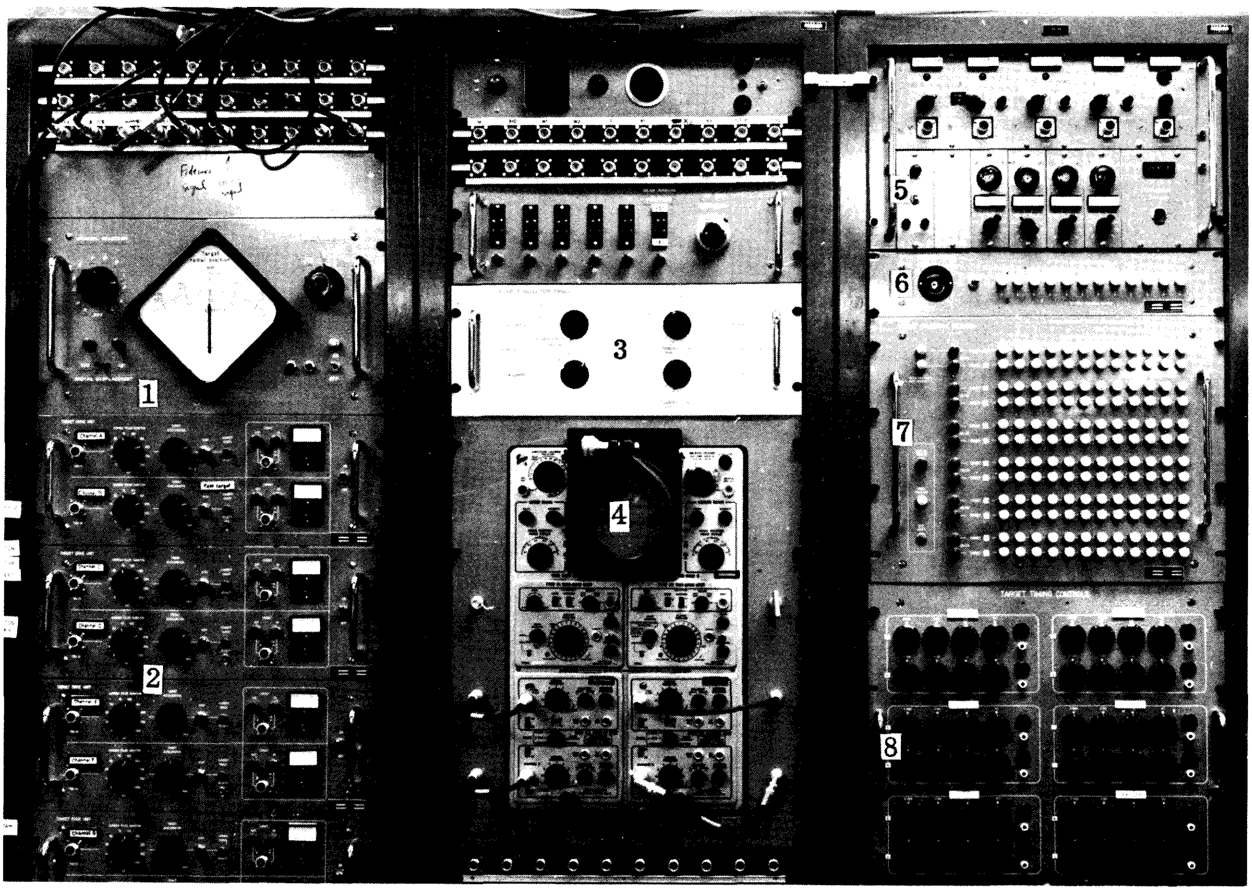


Fig. 6 TARGET CONTROL RACKS IN MCR

1. Control and indication of radial target position
2. Target drive units
3. CRO input selector
4. CRO type 555
5. Standard timing unit
6. Stepping switch (for No. 7)
7. Programme selector
8. Target timing unit

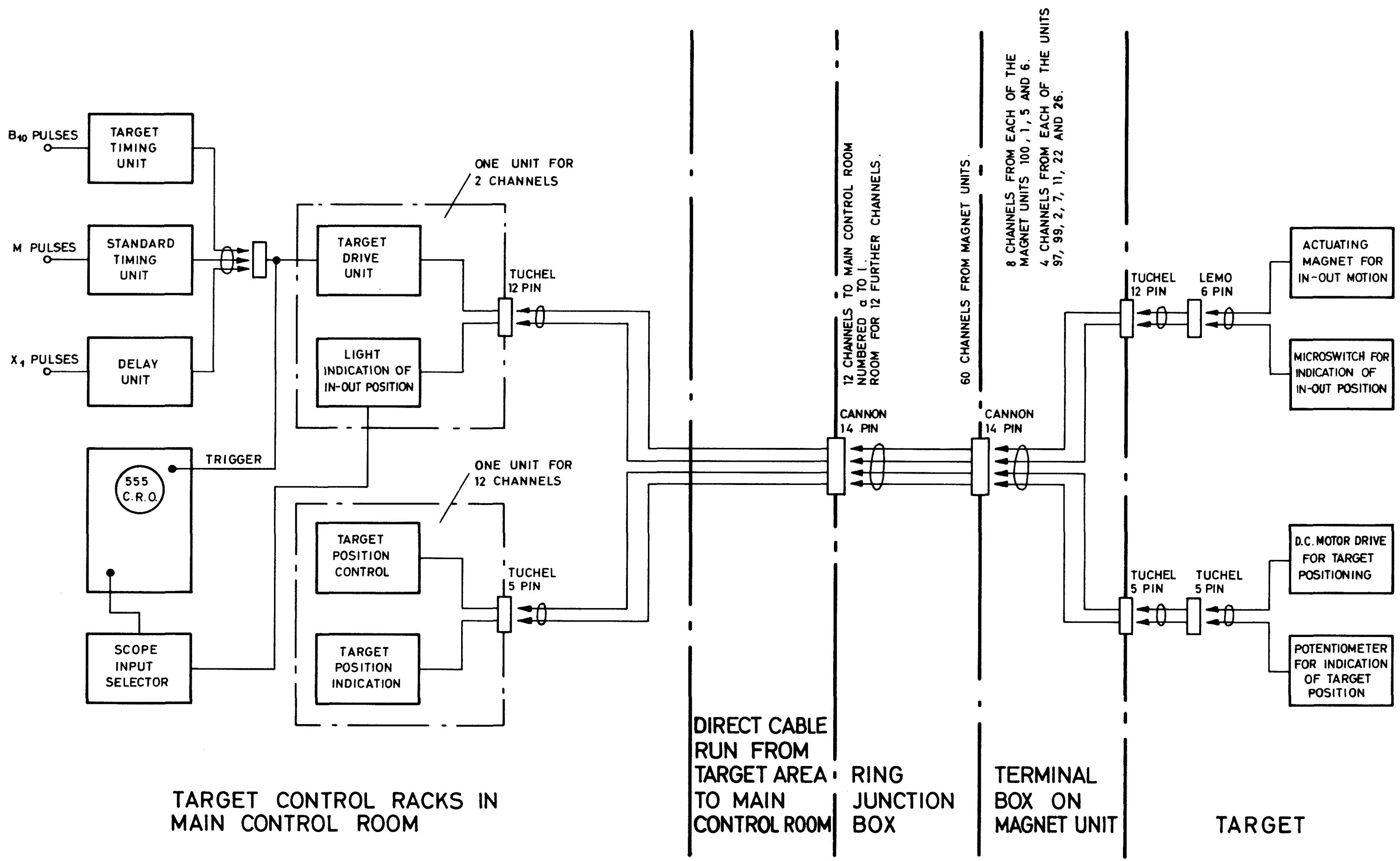
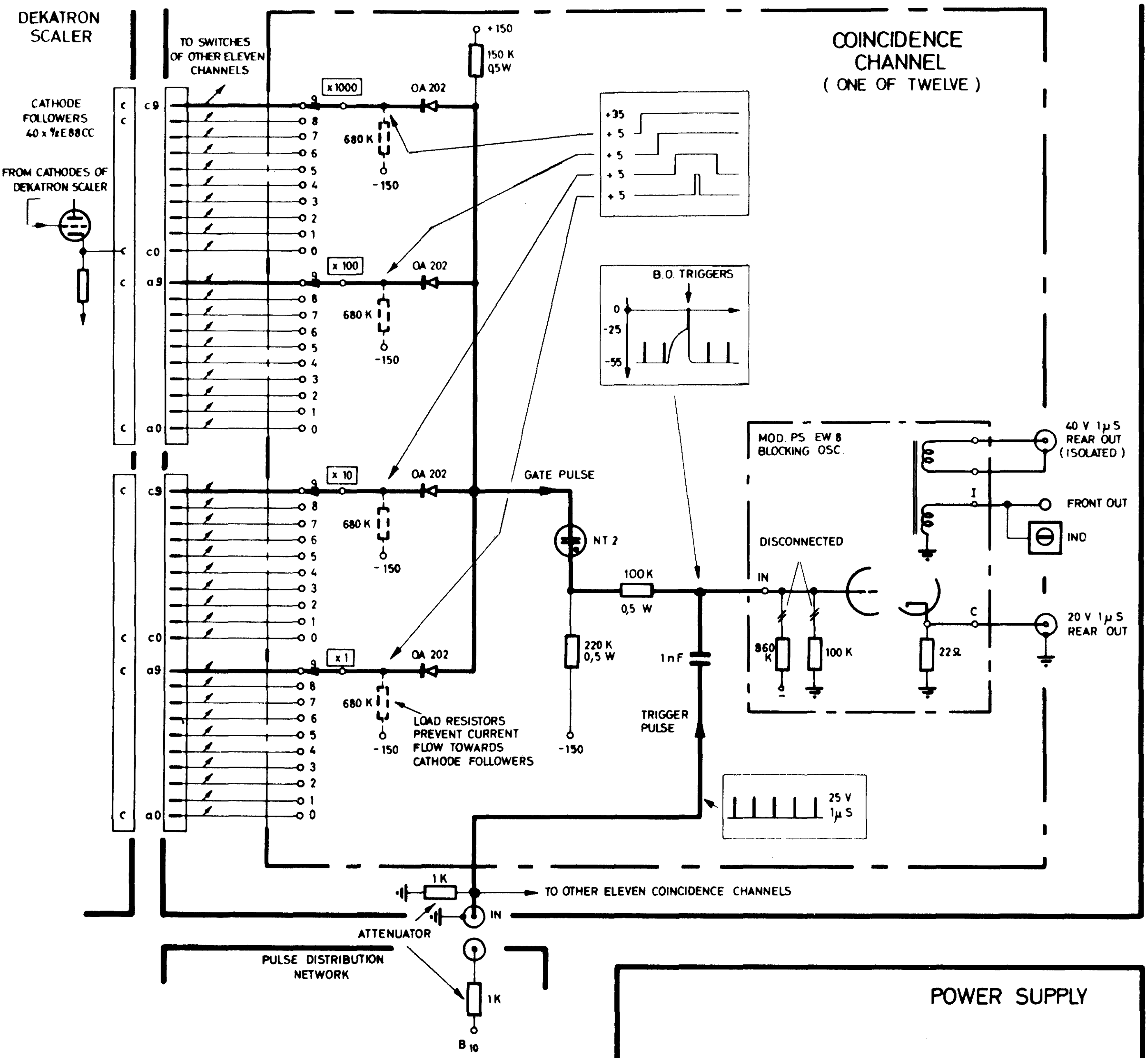
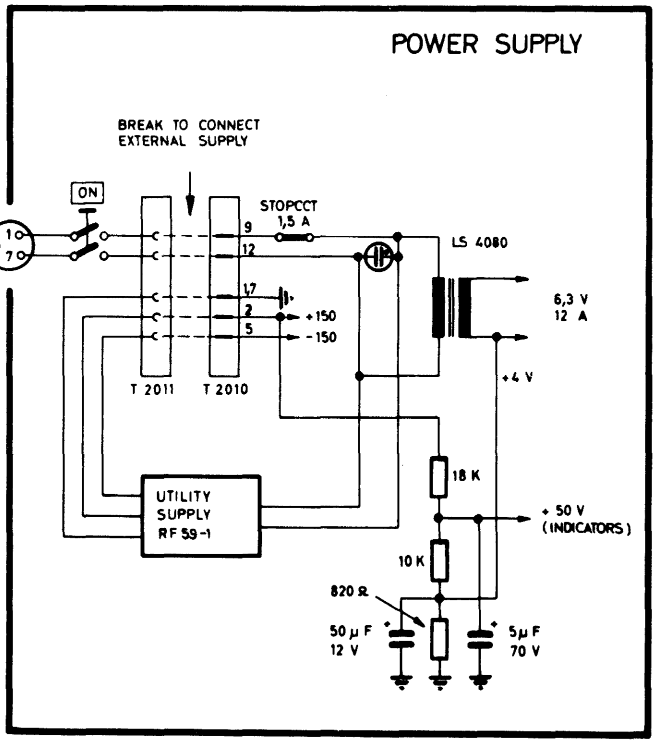


Fig. 7 BLOCK DIAGRAM OF CPS TARGET SYSTEM





DESCRIPTION

USED IN CONNECTION WITH A FOUR DECADE DEKATRON SCALER, THIS UNIT WILL GENERATE TWELVE SEPARATE OUTPUT PULSES WHICH CAN BE MADE TO OCCUR AT ANY DESIRED COUNT OF THE SCALER (1 - 9999+1).

THE BLOCKING OSCILLATORS ARE NORMALLY BIASED TO A POINT WHERE THEY CANNOT TRIGGER. WHEN SCALER HAS REACHED THE COUNT SET UP ON THE SELECTOR SWITCHES OF A COINCIDENCE CHANNEL, ALL FOUR DIODES IN THAT CHANNEL ARE CUT OFF, ALLOWING THE GRID OF THE ASSOCIATED BLOCKING OSCILLATOR TO RISE IN VOLTAGE. THE NEXT TRIGGER PULSE THEN CAUSES AN OUTPUT PULSE AND ALSO ADVANCES THE SCALER ONE STEP, CUTTING OFF THE BLOCKING OSCILLATOR TILL THE SCALER REACHES THE SAME COUNT AGAIN.

Fig. 8. CIRCUIT DIAGRAM OF TARGET TIMING UNIT

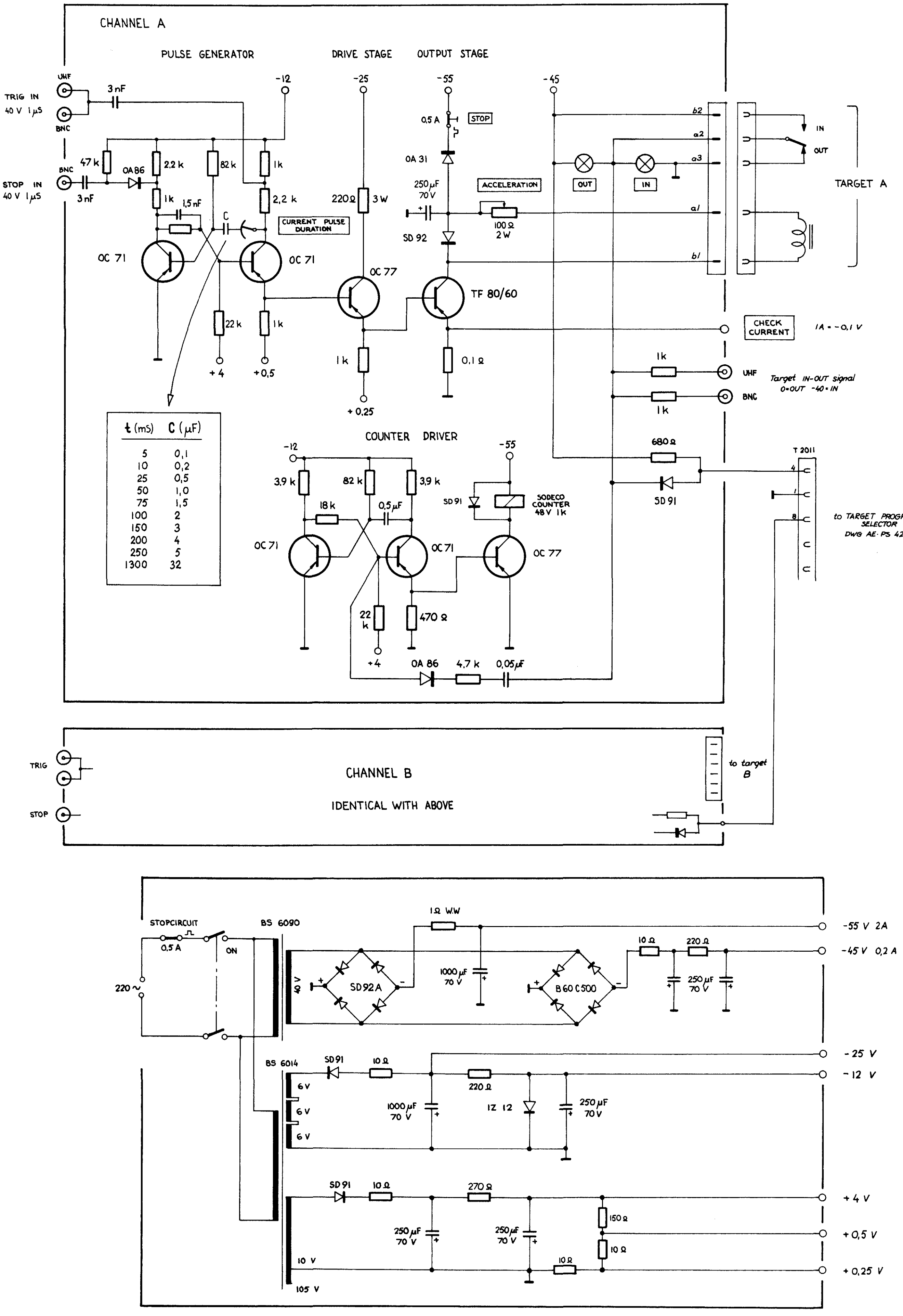
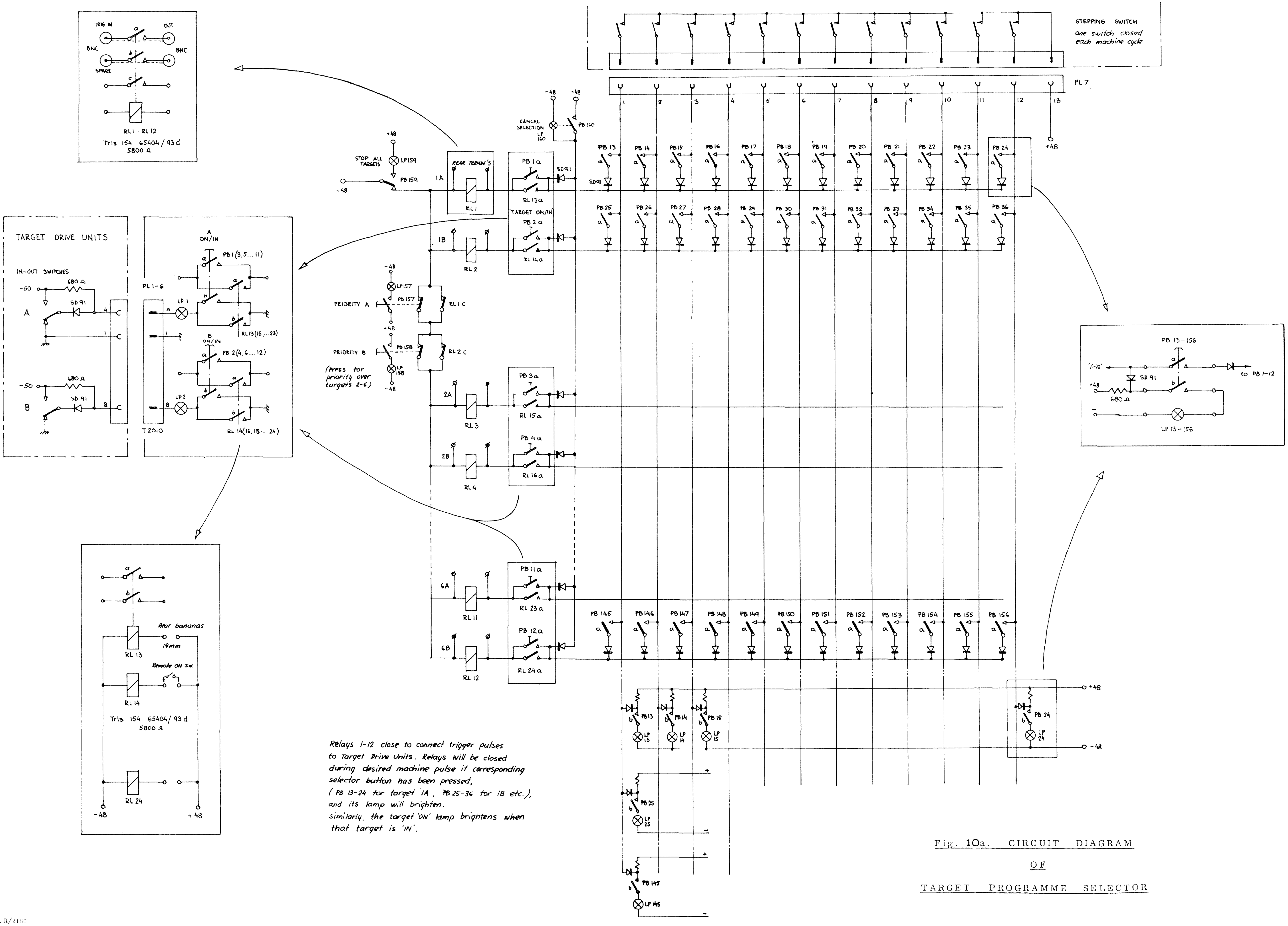


Fig. 9 CIRCUIT DIAGRAM OF TARGET DRIVE UNIT

SIS. R/2183



Relays 1-12 close to connect trigger pulses to Target Drive Units. Relays will be closed during desired machine pulse if corresponding selector button has been pressed, (PB 13-24 for target 1A, PB 25-36 for 1B etc.), and its lamp will brighten. Similarly, the target 'ON' lamp brightens when that target is 'IN'.

Fig. 10a. CIRCUIT DIAGRAM OF TARGET PROGRAMME SELECTOR

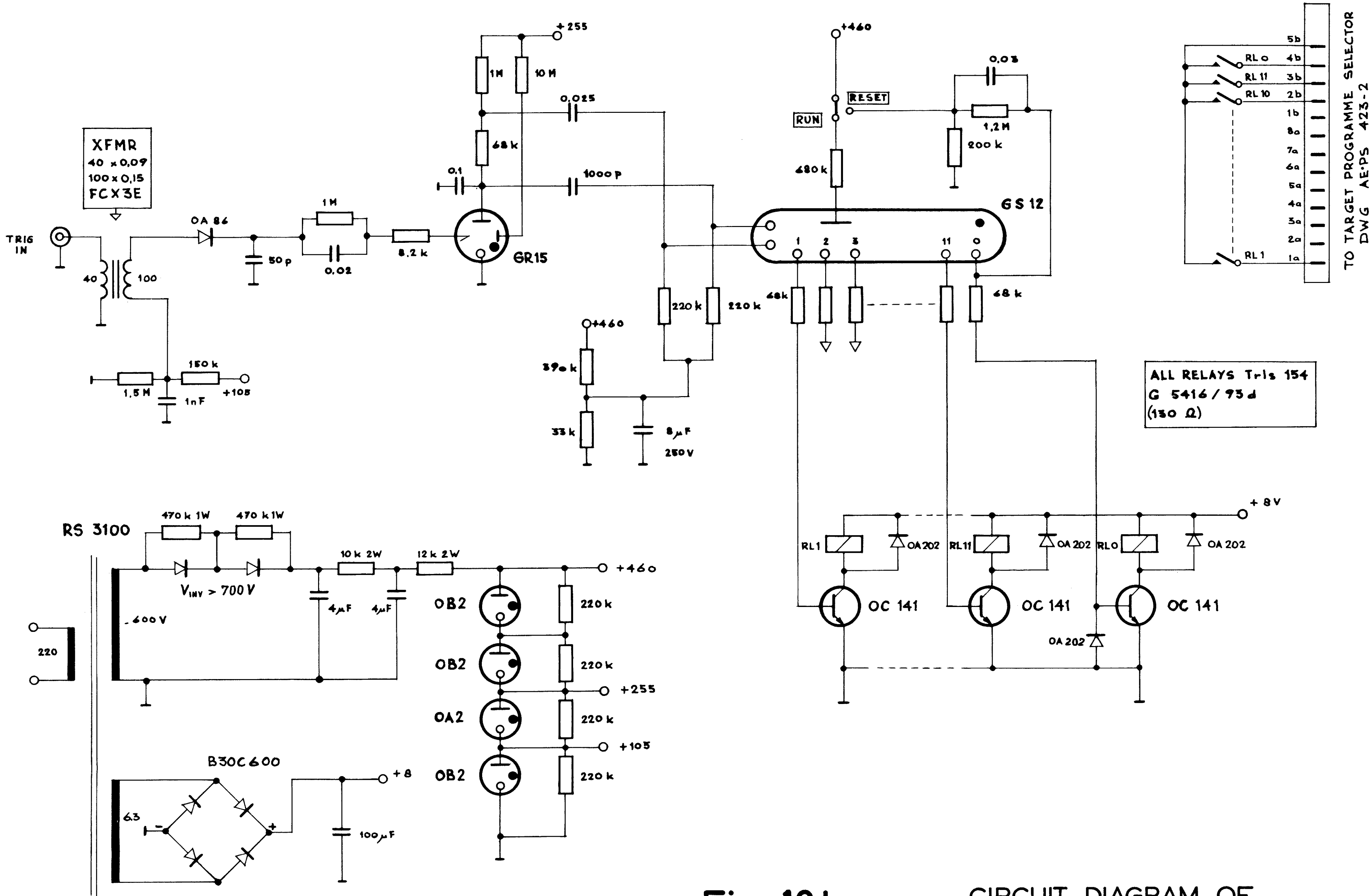


Fig. 10 b

CIRCUIT DIAGRAM OF
STEPPING SWITCH FOR TARGET SELECTOR

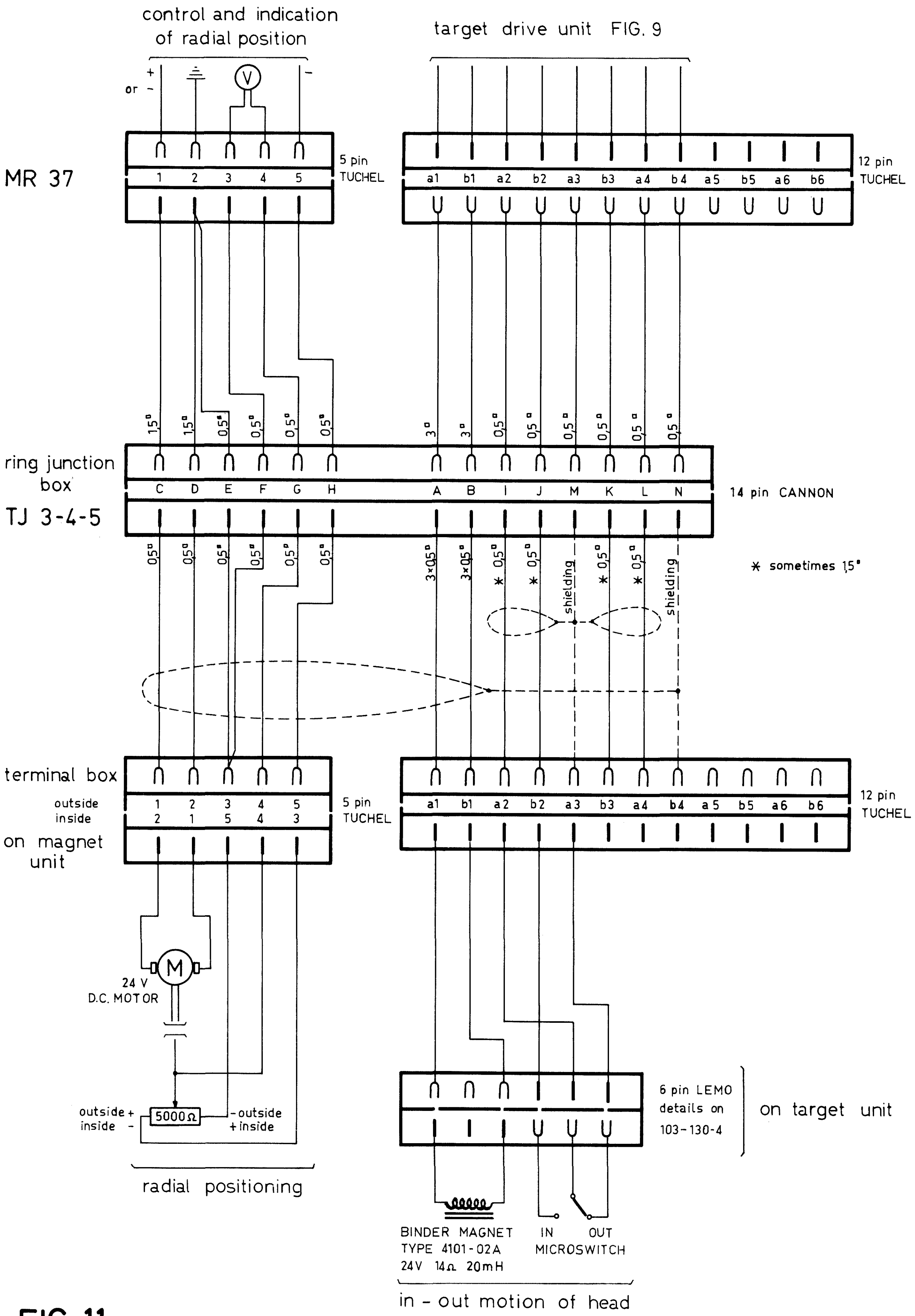


FIG. 11

Simplified cable run for single target