ITEM NO. 9
FILE NO. XII-22

ELECTRONIC TEST INSTRUMENTS SPARK AND FLASH DISCHARGE PHOTOGRAPHIC EQUIPMENT PHILLIPS, EINDHOVEN

COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

INVESTIGATION OF PHILLIPS, EINDHOVEN, WITH REFERENCE TO ELECTRONIC TEST INSTRUMENTS, AND SPARK AND FLASH DISCHARGE PHOTOGRAPHIC EQUIPMENT

3 - 8 December 1944

Reported By

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CIOS Target Number 9/7

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
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SECRET

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Target: No. 9/17. Philips, Eindhoven, Holland.

Subjects of investigation:

(i) Electronic test instruments for physical measurements.

(ii) Spark and flash discharge photographic equipment and photoelectric cells.

Contacts:

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1. Summary

Information was obtained on the following instruments:-

(a) cathode ray oscillographs and electronic switches.
(b) vibration measuring equipment.
(c) pressure measuring equipment.
(d) stroboscopes.
(e) miscellaneous electronic test instruments.

None of these instruments was available from stock, but in most cases preproduction models existed and production was fully planned and could commence immediately electrical power became available. The firm possessed sufficient suitable man-power and showed a keen desire to satisfy our requirements. Their estimated delivery period for small numbers of instruments was three months from re-installation of the electrical supply. The availability of raw materials was in general satisfactory, but there might be a shortage of special materials such as Beryllium-copper sheet.

The firm was prepared to supply any further information on the development or manufacture of their instruments on receipt of an official request.

2. Action recommended.

It is recommended that

(a) the firm be asked for full manufacturing details of their method of damping the diaphragms, their heat treatment and the performance curves of the improved vibration pick-up units.

(b) an order be placed with the firm for the following instruments provided their prices, delivery dates and raw material requirements are reasonable.

(i)	10 off.	electronic switch,	Type GM.4580
(ii)	10 off.	preamplifier,	Type GM.4570
(iii)	1 off.	5,000 volt power unit,	Type GM.4198
(iv)	1 off.	projection unit (for use with oscillograph Type GM.3156.	Type GM.4199
(v)	25 off.	'electrodynamic' vibration detector (absolute)	Type GM.5520.
(vi)	10 off.	electromagnetic vibration detector (without mechanical contact)	Type GM.5527.
(vii)	10 off.	vibration detector (relative) with adaptors.	
(viii)	10 off.	calibrating unit,	Type GM.5522.
(ix)	2 off.	pressure indicator - amplifier and oscillograph	Type GM.3158.
(x)	2 off.	pressure pick-up unit, 10 atoms.	
	"	" 30	"
	"	" 50	"
	"	" 70	"
	"	" 100	"
	"	" 150	"

All units to have standard British 14 mm. sparking plug threads.

(xi)	1 off.	piston movement indicator, capacity type (for aero-engine work).
(xii)	1 off.	high intensity stroboscope.

Note. It should be emphasized when ordering that all instruments should incorporate the results of all recent developments.

(c) A contract be placed on the firm for the development of a vibration exciter comprising the following units:-

V.L.F. oscillator down to 0.25 cycles per second with hand and motor driven continuous frequency variation.
50 watt power amplifier for amplification of the oscillator output. Exciter unit of the loud speaker type for use with the oscillator and power amplifer.

3. Cathode ray oscillographs and accessories.

3.1 Cathode Ray oscillograph.

The following types of oscillographs had been produced during the German occupation:-

GM.3152: Universal high frequency oscillograph.
Vertical deflection amplifier - 1,000 kc/sec. sensitivity - 6 mV r.m.s. per cm. picture height.
Time base - 2 to 150,000 c/sec.
Screen diameter - 9 cm.
A.C. mains driven, 110 to 250 volts
40 to 100 c/sec.

GM.3155: Servicing oscillograph.
Vertical deflection amplifier - 25 to 100,000 c/sec.
Sensitivity - 830 mV r.m.s./cm.
350 " "
and 125 " "
Horizontal deflection amplifier - 25 to 100,000 c/sec.
Sensitivity - 700 mV r.m.s./cm.
Time Base - 20 to 20,000 c/sec.
Screen diameter - 7 cm.
All mains driven.

GM.3156: Low frequency oscillograph.
Vertical deflection amplifier - 0.1 to 10,000 c/sec.
Sensitivity - 1 mV. r.m.s./cm.
Time base - 0.25 to 2,000 c./sec.
Screen diameter - 9 cm.
All mains driven.

These three oscillographs were marketed by Messrs. Mullard in Britain prewar and no further developments had been made by Philips. A battery operated direct coupled preamplifier, Type GM.4570, had however been developed for use with the oscillograph Type GM.3156 giving a combination with a total gain of 350,000 times.

A new completed development, called a "phasing" oscillograph, was demonstrated satisfactorily. This is on the same general lines as the above but has both vertical and horizontal deflection amplifiers with a frequency range 25 to 50,000 c./sec. and sensitivities of 25 and 35 mV. r.m.s./cm. deflection respectively in addition to a hard value time base generator with the frequency range 10 to 120,000 c/sec.

3.2 Electronic switch.

A two way switch, Type 4580, with a switching frequency variable over the range 3 to 40,000 c./sec. and containing two amplifiers each responding in the frequency range 0.1 cycles to 350 kilocycles/sec. was demonstrated. This is a distinct improvement on their prewar model both in switching circuits and amplifier responses and it is considered a useful accessory to the oscillograph Type GM.3156 for two channel recording of physical phenomena and for general measurements of phase differences.

3.3. Cathode ray oscillograph projection equipment.

This consists of a 0 to 5,000 volts D.C. power supply Type GM.4198, for use with an oscillograph fitted with an intensifier tube and an optical projector, Type GM.4199 designed for attachment to the oscillograph Type GM.3156. It projects the magnified cathode ray tube pattern on to a screen one to five meters distance and would thus be a valuable accessory for laboratory use.

The complete equipment has been in production.

4. Vibration measuring equipment

4.1 Pick-up unit - prewar, Type GM.5520.

The following information was obtained on the design and performance of the seismic electromagnetic generator type pick-up unit manufactured by Philips prewar and marketed by Mullard in Britain:-

(a) Materials:-

body - soft iron of commercial purity.
damping cylinder - copper of commercial purity
permanent magnet - ticonal or its equivalent
diaphragm - beryllium-copper.

(b) Failure of the diaphragms under severe vibration had been experienced and a thorough investigation of the causes made. It was claimed that a special heat treatment and manufacturing technique had been developed which resulted in an improved diaphragm. It was found impossible to make these details available during the visit and it was therefore arranged that they be forwarded on receipt of an official request.

A second source of trouble in the pick-up which had received much attention was the existence of subsidiary resonances at comparatively high frequencies due to the harmonic excitation of the diaphragms. This investigation had resulted in an improved pick-up incorporating diaphragms damped by the application of a thin coat of polystyrene material. Complete details of this were also promised on receipt of an official request.

(c) The sensitivities of production units were matched by controlling the intensity of the permanent magnet after assembly of the complete magnetic circuit.

It is considered that the above constitutes a distinct improvement in the pick-up design.

4.2 Other types

(a) Type GM.5527

This is an electromagnetic generator type, but is not seismic and has to be fixed rigidly to ground in the immediate neighbourhood of the vibrating body which must consist of a magnetic meterial.

(b) A further type, referred to as a relative pick-up unit, has been developed for measurements of relative motions between two points, whirling and surface undulations.

(c) The development of a smaller and lighter unit and a seismic unit responding to frequencies below 10 cycles per second is contemplated, but not yet started.

Units (a) and (b) supplement Type GM.5520 and widen the field of application of this vibration measuring technique. The production of all these pick-ups incorporating the results of all recent developments has been planned.

4.3 Associated electronics

These pick-up units are used in conjunction with the calibrating unit, Type GM.5522, and cathode ray oscillograph, Type GM.3156. No development of this equipment has been undertaken since the war.

4.4 Vibration exciter

The firm's development of a vibration exciter for the artificial excitation of specimens for resonance investigation was discussed, and parts of the equipment demonstrated. It consists of a very low frequency oscillator, 50 watt power amplifier and an exciter of the loudspeaker type.

The oscillator is an R-C type, specially designed for mechanical vibration work, with frequencies continuously variable, by hand or by a motor drive, down to 0.25 cycle/sec. Its electrical design is completed and the design of the amplifier and exciter are proceeding.

An equipment of this nature has numerous applications to vibration investigations and it is considered that the development should be encouraged.

5. Pressure measuring equipment - Type GM.3158

An equipment for the measurement of hydraulic and pneumatic pressures using a variable capacity type pick-up unit was discussed and demonstrated.

5.1 Capacity type pick-up unit - Types GM.5562 and 5563

This consists of an air dielectric condenser whose capacity of about 10 pfs. is varied by about 5% by the application of pressure to a diaphragm. It is designed primarily for use on single cylinder aero engines and its main feature is temperature compensation without recourse to water cooling. It was claimed that the unit was accurate and in every way satisfactory over long periods at a temperature of 500°C. This performance is attained by including in the unit a second condenser whose capacity varies with temperature in such a manner as to neutralise the temperature sensitivity of the "measuring" condenser and by using a metal which will withstand these temperatures for the diaphragm.

5.2 Associated electronics

The pick-up unit capacities form part of a capacity bridge, the remainder comprised of fixed condensers housed in the pick-up head. The bridge is energised with alternating current at a frequency of 450 kilocycles/sec. in such a way that a long length of cable may be used from the pick-up head to the associated equipment.

The high frequency carrier is modulated by the capacity variations of the measuring condenser and the modulated signal is amplified and detected before application to a cathode ray oscillograph incorporated in the equipment. In this way response to steady and slowly varying pressure is obtained without the use of a direct coupling in the amplifier. The amplifier is also designed to pass modulation frequencies up to 15 kilocycles/sec. Its response is such that it corrects for the hyperbolic capacity variation with pressure.

5.3 Piston movement indicator, Type GM.4302.

This is a rotating condenser type designed for a maximum rotational speed of 6,000 r.p.m. The equipment is such that the variations in pressure as a function of time or piston movement may be obtained.

5.4 The basis equipment was designed prewar but improvements in the temperature compensation of the pick-up and the amplifier response are the result of secret development work during the German occupation. The equipment had been used on an engine at the Shell Factory, Delft.

The main disadvantage of the instrument is the comparatively large size of the pick-up unit which makes its universal application to aero engines impossible. It can, however, be used on some types of engines and for other pressure measurements and is considered a valuable instrument, especially if the claim for its performance at high temperature is correct.

5.5 The application of the capacity and piezo-electric techniques to measurements of detonation are under consideration by the firm.

6. Stroboscope.

A high intensity stroboscope has been developed since the war and a preproduction model was demonstrated. It incorporates a new design of lamp and gives seven different intensities up to a maximum of 2 million lumen. The flash has a duration of 10 microseconds and its frequency is continuously variable in the range 0.5 to 250 cycles/sec. The design allows synchronisation of the flash with an external contact and single flashes. The instrument is fully developed and ready for production. It is considered a very useful tool for the engineer both for visual and photographic work.

6.2 The firm has no stroboscope similar to the General Radio Strobotac and does not manufacture a small lamp on the lines of the strobotron.

7. Miscellaneous electronic test instruments.

7.1 Universal measuring bridge, Type 4140 and 1,000 cycle oscillator, Type 4260.

No further development during war.

7.2 Valve voltmeter, Type 4132.

Mains operated with ten ranges from 0 to 10 mV up to 0 to 300 volts; frequency range 25 cycles to 15 kilocycles/sec; input impedance 1.2 megohms.

This was a new development ready for production and seemed to be a good instrument.

7.3 Audio frequency oscillator, Type GM.2307.

Frequency range 30 cycles to 16 kilocycles/sec. Incorporated improvements, such as higher stability with mains and temperature fluctuations, on the prewar model.

It was stated that an order had already been placed for a number of these instruments.

8. Spark and flash discharge photographic equipment.

The firm had done no work on this type of equipment and did not manufacture special components for such equipment.

9. Photoelectric cells.

No photoelectric cell development had taken place during the war, the present types being similar to those marketed by Messrs. Mullard prewar. The only application of photoelectric cells in which the firm was interested was sound reproduction.

10. General observations.

It was apparent from the keen interest shown in the subject discussed that the firm attached much importance to the application of electronic techniques to physical measurements and were aware of the future fields of application. Their knowledge was sound, although some-

what out-of-date due to lack of facilities, during the German occupation, to keep in touch with current developments.

Their appreciation of the special nature of the problem, differing from that of standard radio practice, was apparent from their work on the development of nigh qualtiy components, such as switches, resistances and condensers, specially designed for use in measuring instruments.

10.2 The firm's organisation for this type of work is good. Its basic feature is specialisation on development work, each particular technique, e.g. electromagnetic or capacity, being the responsibility of a particular group of specialists. The organisation also allows of small scale production of these instruments.

10.3 Specialist tuition in this work is given by the firm's own educational organisation.

11. German interest

It was apparent to Philips that the Germans were in great need of electronic measuring instruments. Very few, however, had been delivered. Appreciable development had proceeded secretly during the occupation and it was stated that none of the resulting improvements had been incorporated in instruments delivered to the Germans.

The following specific information was obtained:-

(a) Oscillograph, Type GM.3156 - large orders had been placed and a few instruments delivered.

(b) Oscillograph, Type GM.3156 and Measuring bridge, Type 4140, were being manufactured in Germany.

(c) Pressure indicator.

25 had been delivered to Germany and were used mainly for measurements of blast from explosives. An unsatisfactory demonstration of its application to engine indicating, using a pick-up which was not compensated for temperature sensitivity, was given on a single cylinder engine at Motoren Fabrik, Brandenburgh.

The existing German engine indicator uses a piezo-electric pick-up unit and is made by A.E.G., Stuttgart.

(d) The development of the stroboscope had been initiated by the Germans, but no instruments had been delivered.

(e) It appeared that most German test instruments were made in the development laboratory.

(f) A very high priority was given by the Germans to the manufacture of valve voltmeters and audio frequency oscillators.