Ben Duncan Research - UK

'Extra-Wide' Laboratory (Test & Research) Facilities

Electromagnetics - Logistics - Forensics E.L.F.

Electronic & Electrical ◈ Scientific & Technical

❋ *Abbreviations* ❋

A = analog (needle) indication - where not digital (numeric) readout
AP S1 - Audio Precision Inc *System One* (master audio test set)
✧ BDR = in-house-developed or BD adapted equipment
✧ b.s.a. = *b*y *s*pecial *a*rrangement c/w coupled with
✧ C-Lim = Current-Limiting (simple or re-entrant)
✧ CSR = Current Sensing Resistor ✧ CTR = Current Transformer
generic - 'OEM' unit; or of far-eastern provenance
MOD = UK Min of defence (or contractor thereof)
✧ opts = options ✧ P/ins = Plug-in/s
✧ trms = true rms value ✧ w/ = with

❋

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E&OE. All information is indicative

The following listing of over 260 categories aims to delineate some of the extensive envelope of measurement capability at **Ben Duncan Research**, together with an indication of the equipment make/s, that furnish the indicated capacity/capacities. Additional global information is provided in the Appendix.

1 . Basic Electrical Quantities

1a. Voltages in Volts - using Voltmeters

1a1/a DC: down to 1nV ; and millivolts thro' >1kV, with *multiple*-digit resolution – Datron.
1a1/b DC, very high impedance - Fluke (A), Datron (eg. 10GΩ < 2v). *See also* AC Voltage, section **5j**.
1a1/c DC, analog readout for *trends* - Airmec, Bradley (A).

V High voltage >1kV - *see* EHT laboratory, section **6**.

1a2/a AC, trms, below 10nV to 1.2kV, trms, <10Hz to 2MHz - Datron; Keithley, Racal-Dana.
1a2/b AC, avg (non-rms) Analog readout for trends - Airmec, Bradley, Levell, Sangamo-Weston (all A).
1a2/c AC, analog Log./dB, *w/ plurality* of decades for extreme all-in-one wide range - HP (A).
1a2/d AC, analog for trends & audio, Log./dB, <10Hz to >1MHz, >100dB in 10dB sections - Levell (A).
1a2/e AC, digital, auto-ranging, selectable trms, pk, <1µV to 300v, 10Hz to 500kHz - AP S1.
1a2/f AC, *max of peak* hold - BDR; *max of rms* hold - Datron.

V High voltage >1kV - *see* EHT laboratory, section **6**.

1b. Currents, in Ampères - using Ammeters - *and shunt-adapted* voltmeters

low - DC
1b1a DC, electrometer down to <1pA (fA) - Keithley (A).
1b1b DC, down to nanoAmpères (nA) with *multiple digits* resolution - Datron.

low - AC
1b2a AC down to < 1 µA, up to 2MHz, trms, with multiple digits resolution - Datron.
1b2b AC floating/isolated, down to ≦ 100µA AC & up to 100kHz - via CTRs, HP & Tek.

mid - DC & AC
1b1c DC with 8 digits resolution, up to 2.000,000 - Datron.
1b2c AC trms up to 7 digits, <10Hz up to 2MHz - Datron.
1b2d AC trms w/high Crest capacity (10:1 = 20dB), up to HF/low RF - Solartron (A).

high - AC & DC
1b2e AC CTRs access 1~5kA, to 3.3kV, fixed & openable, 50Hz to ⩾100kHz - HEME; Fluke, Keithley, Tek; Chauvin-Arnoux, HEME-LEM.
1b12a AC/DC CSRs, <1A to 10kA, DC to >1MHz - AVO, BDR, Hobbut;
1b12b AC (only) & AC/DC analog, for trends, many w/ high visibility:
fsd 5A to 30A - Elliott, GEC, Sangamo-Weston (A).
fsd 100A thro' 1000A - MOD, various (A).
1b2f AC, electronic, full-wave peak-hold, to 250A through 250kA (remote/ext. shunt) - BDR (A).

For **Power & Energy** measurement (in mW, Watts, kW) - *see* sections **5e** & **5f** ⇨

For **V/I ratio quantities** & Component Characterization, *see* next ↓

1c. Resistance in Ohms, using Ohm-meters & Mega-ohm meters

Low activation voltage -

Low ohms

1c1. down to below 100 nano-ohms(nΩ), at 10A thro' 100A - BDR.

1c2. to 1 micro ohm and below at 100mA thro' 10A - BDR w/Bradley+Datron.

1c3. down to 1μΩ at 10A, w/peak hold - AVO (A).

1c4. Low-current bi-polarity to 1mΩ for micro-contacts - Keithley (A).

1c5. Wide range, bi-polarity, <1mΩ to > 100Ω - Cropico.
Note: True bi-polarity is required for saturable windings, also for asymmetric junctions.

1c6. AC (50Hz) low-ohms: see **Bond Testing**, in section **5h**.

Mid ohms

1c7. 1 ohm to 20MΩ, 6 tho' 8 digits - Datron, Racal-Dana.
Attention! Only certain instruments are safe for testing of Tunnel diodes. See Curve Tracer ⇨

High activation voltage -

High ohms

1c8 to >100 GΩ (1e12) with applied voltage 100v thro' 1kV - AVO, Megger; GenRad (all A).

1c9 to tens of GΩ = 1e13, or as the equivalent current - Keithley (A).

1c10. Dual Potentiometer Matching - for LF, audio, stereo & balanced sys. - BDR & w/AP S1.

1c11 Lead (operational cable) testers - **see** Section 3k/1, Audio/LF ⇨ Signal Cable Verification.

1d. Generic VAO (Volts - Amps - Ohms)

1d1 DMMs (with numeric readout) for generic V (DC, AC), A (DC, AC), and Ohms (Ω) measurements include age-stabilised Datron 1041 thro' 1061/65; and Fluke, Keithley; Racal-Dana; Solartron, Thurlby.

1d2 Multimeters with needle readout (A) - all active, solid-state incl. dedicated coverage units - Bradley, Levell; Fluke, Milli-VAC. Also valve (Airmec) - for spike handling.

1e. Capacitance

0.3pF thro' 5000,000µF (5 Farad), for C, tol., R_S, ESR, Q, D, R_p, *et al.* - Marconi (A), Peak, Thandar, Thurlby (TTi), Wayne-Kerr (A); Philips.

1f. Inductance

0.1µH thro' 500 kH, for L, tol., Q, D, R_S & ESR, R_p, *et al.* - Marconi (A), Thandar-Thurlby/TTi, Wayne-Kerr (A); Philips.

2. Time & Frequency - in Seconds & Hertz

2a. Scopes - Analog realtime & storage *Cathode-Ray Oscilloscopy*

- facilitating the viewing of electrical wave patterns in 2.1 dimensions - as amplitudes observed over time.
- capturing events lasting under 1 nanosecond.
- time strewn imaging with analog storage readouts - enabling complex sequential events to be visualised.

2a1a Field Portables, up to 250MHz - Tek; Cossor.
2a1b Field Portables, up to low MHz, Balanced/diff. - Telequipment; HP.
2a1c Field portables, up to 600MHz w/balanced/diff. - Tek/BDR.
2a2a Storage field Portables, up to 100MHz - HP.
2a2b Storage field Portables, up to low MHz, Balanced/diff. - HP.
2a3 Lab semi-portables/bench, 4 ch., in 2, 3 & 4-bay frames - HP, Tek.
2a4 Rack mountable - Solartron; Tektronix 76*xx*-R type.
2a5 Bench and indicating scopes◇ - Tektronix, HP; Cossor, Scopex - *see also* 4c ⇨
2a6 Auxiliary digital storage & capture - outboard accessory for analog oscilloscopy - Datalab.
2a7 Oscilloscope trolley (cart). All bench scopes can be brought up to the largest work (vehicles, industrial units).
2a8 'Scope cameras - HP, Tek. See also **4c3**.

◇ Indicating scopes are used for visual monitoring. Multiple units (of the same model/s) are used to show multi-channel information (stereo, de-multiplexed, etc) ; or one signal with different time or amplitude magnifications - with a common screen format. See also 4c ⇨

2b. Counters - Frequency Counters & Indication ¶

2b1. Digital counters, pico-seconds (1e-12) to kilo-secs (1e3s). Up to 2GHz, up to 9 digits - Racal.
2b2 Low end numeric frequency indicators/counters, vlf (<1Hz) thro' 100kHz - TTi; AP-S1.
2b3 Other numeric frequency indicators/counters, low thro' high RF - Racal, Thandar, TTi; HP.
2b4 Mechanical frequency indicators for 40-70Hz. Dial readout (A). For trend monitoring & synchronising.

¶ Note: Strictly speaking, 'frequency' is *never* a thing (*ding an sich*). It an abstract concept, the *rate* of some activity. Neither the rate nor the activity are ordinarily *things*. So, it is *doubly* abstract. Therefore, indication is the more apt title, than *meter* or *metering*.

3, 4, 5 - Frequency Domain ~

for Signals and Waves, categorised into 3 areas, based on rates -

1. LF for Power transmission - usually 50, 60 or 400Hz.
2. All other LF - above & below, incl. audio range. Ends 100kHz~1MHz.
3. HF/RF - Radio Frequencies. Starts 10kHz ~ 100kHz.

3. Low Frequency (LF) *incl.* Audio (sub-1Hz, thro' 100kHz ~ 1MHz)

3a1. Sine (pure) wave Generators

Up to 10kHz w/ultra low dist. avg down to 2ppm /0.0002% & up to 200kHz w/ult-low dist; up to 40v rms bal w/medium level low-order dist. - AP S1 & HP; Advance, Bateman/BDR, BDR, Levell.

3a2. Function (varied wave) generators

Square, triangle, random, dual-ch, bi-polarity & complex, <1Hz to >1MHz - GWI; Systron-Donner, HP.

3a3. Noise (random wave) Generators

3a3a LF up to low MHz, white noise w/magtube - Dawe; GenRad.

3a3b VLF < 1Hz to 20kHz, pink & white bandgap gen., indep'ly settable HPF & LPF, *exceeds* **EIA/AES** LS test reqs - BDR *(after C.Hendricksen).*

3b1. Spectrum (wave) Analysis (SA)

3b1a Spectrae of noise, ⅓rd octave sweep (swept RTA), w/advanced data-averaging options - AP S1.

3b1b Spectrae of harmonics, 0-10th, swept analog Realtime (RTA) - HP, Nelson Ross.

3b1c Spectrae of Harmonics, FFT - HP, Spectral Dynamics.

3b1d Audio band bargraph analysis, programmable bands w/pk-rider LEDs - BDR, Ivie.

3b2. Harmonic Distortion Analysis

Sine wave purity-deviance, as Harmonic dist., %THD+N; IM - ***all measures of non-linearity***

3b2a Auto, hi-res - AP S1.

3b2b Auto, ultra hi-res to –140dB/0.1ppm - AP Sys1 c/w SA ⇨ see 3b1 above ↗

3b2c Manual - Radford, w/BDR mods, HP.

See also **3q** for purity aids ⇨

3b3. Noise Analysis

Squark audio monitor, compressed for aural analysis of noise residue eg. from AP Sys1 Noise Anlr o/p - Reddingwood/BDR. *See also* 3b1, above ↗

3c. Phase Voltage-to-voltage, a.k.a. Signal phase.

for V/I phase a.k.a. 'power phase' - see **3h3**, **3h4**; also **4d**, **5f** ⇨

3c1. VLF to >1MHz, 4 to 5 digits - AP S1, Dranetz (stereo pair).

3c2. Phase Angle VOM - North Atlantic.

3d. Polarity

Below 10Hz to above 20kHz, impulse-type polarity test sets - Turbosound, Funktion One Research.

3e. Acoustics Ancillaries

3e1 SPL meters - generic handheld, calibrated against reference; B&K - b.s.a.

3e2 Mic mounting & SPL-monitoring stands - Penny & Giles.

3e3 Acoustic test gen. up to 100 acoustic Watts ≅ 140dB$_{SPL}$ @ 1m - Turbosound; Funktion One b.s.a.

3f. Analog Signal Sources

3f1 Mic Amp, Mic amplifier transformer & Mic Splitter Investigation/s

3f1a Mics, Dyn & Capacitor - Beyer, Calrec, EV, Sennheiser. Also AKG; B&Kjaer b.s.a.

3f1b Cable runs up to 1km, twisted & shielded pair cabling.

3f1c Phantom power, +9 to +48v, balanced, and unbalanced (Calrec standard).

3f2 Disc playing - Investigation & signal source

3f2a Vinyl Turntables, Arms & Cartridges. Classic makes b.s.a.

3f2b Vinyl source material. Test Disks.

3f2c Vinyl speed adjustment - fixed frequency changers, BDR. See also **9c31** ⇨

3g. Loudspeaker & headphones Investigatory

3g1 LS Voice coil thermometer - BDR.

3g2 LS Voice-coil gap capacity test kit - Doddmark.

3g3 Tweeter/HF voice coil protector & real power analyser - BDR.

3g4 Crossovers, Passive/fixed & active/programmable - BDR, Turbosound.

3g5 Power amplifier drive to 2kW - BDR, BSS Audio, The Chevin, Caudio, HH, Otis, Rauch, Turbosound.

3g6 Headphone Amp driver, wide ranging < 20Ω to above 600Ω - BDR.

3h. Power Amplifier Investigatory

3h1 Test loads < 1Ω to ⩾64Ω at 10w to 10kW DC to 100kHz - BDR.

3h2a Test loads, artificial (LS simulatory), LF thro' HF, to kW - BDR.

3h2a Test loads, LS varied drivers, LF thro' HF, up to 1kW, M-coil & ES - BDR, EV, Fane, PD.

3h3 VI Analyser - Baxandall/BDR.

3h4 VI-Space Probability Density analyser/recorder system - BDR.

3h5 PA test supply variable ± 10v to 60v, 20A or 120v DC, 10A, with biasing setup - BDR.

3h6 Timed Short-circuit test generator, 200A rated.

3h7 Shunts, Stereo, Biasing kit, insulated with fused DMM linkage - BDR.

See also Noise generators (3a3, above) ↗

3j. Signal isolation (galvanic, analog)

3j1 1:1 & 1:10 - typ < 10Hz thro' >20kHz, & ≥ +20dBm - BSS; Gertsch/Singer; Lundahl;

3k. Signal cable verification

3k1 Lead Testers - BDR, Behringer, EMO, Reddingwood.

See also **4f**, **5d5**, **5j** ⇨

3m. EMI/EMC

3m1 Test jigs to interface diverse cabling & systems to XLR (bal) & BNC (bal & s/e) - BDR.

3m2 LF magnetic EMI 'Hummer' test set, w/Test jigs to interface w/XLR ConSys - Windt/BDR.

3n. Fault Event - Survival Testing

3n1 DC Fault injection simulation bi-polarity test jigs & access - BDR.

3n2 Various & specific non-disclosure jigs.

See also **3h6** ↗

3p. Power Delivery - of power amplifiers & line stages *(at specified low %THD levels)*

< 1mW to > 4kW, 10Hz to 30kHz for dist. limits <0.001%; up to 200kHz for dist limits <0.01%. Where power into pure resistive load, accurate voltage reading suffices. AP Sys1 for freq. swept plots - AP S1, Datron, Feedback, Marconi.

3q. Filter sets

3q1 - Passive. For set-up patches, special harmonic distortion test operations - Allison Labs.

3q2 - Active. BSS Audio, EMO, Klark-Teknik - bsa.

RF Laboratory

4. RF (Radio Frequencies) - 10/100kHz up to SHF/Microwave

4a. RF Signal Generation (generally >10kHz or 100kHz, to >1GHz)

4a1 - Sine & modulated w/ AM & FM

4a1a Manual, dial and numeric entry, 100kHz to 1300MHz; - Marconi; Tektronix, HP.

4a1b Manual, dial and numeric entry, 1GHz thro' 11GHz - HP.

4a1c Sweepers <10kHz-200kHz, AP Sys1; >1MHz thro' 1.3GHz, extensible to 4 GHz - Marconi, HP.

4a1d Power generator, > +20dBm, UHF - R&S.

See also **4k2**, for LPF - used for harmonic purity enhancement ⇨

4a2 - Noise

Micro-Amplitude, fine-grain white noise, low MHz thro' 1GHz - R&S.

See also **3a3** ↗

4b1. RF Level

Up to 2GHz, CW/AM detection - Bradley, Racal; MilliVAC.

4b2. RF power

4b2a Up to 30W - Welz/RS; Bird.

4b2b High-accuracy thermal, up to 11GHz, µW to >1watt - HP.

4b3. RF Test Loads

4b3a 1 Watt (in-line) up to 1kW under-bench, 50 & 75Ω, up to 1GHz - Bradley, Marconi; Bird, HP.

4c. Scope Monitoring & Observation - Realtime Analog(ue)

4c1 Nominally up to 450MHz, view to >1GHz w / sub-1nS T/B - Tek frames & p/ins.

4c2 Multiple storage options, viz. bistable, single, fast, variable persist. etc - Tek & HP analog storage.

4c3 Scope Cameras, 1960s-70s bodies mounting digicam - HP, Tek, w/ BDR adaptations.

4d. Signal, Spectrum, Tracking & Network analysis

4d1 100kHz thro' 1.25GHz; up to 22GHz with Heterodyne P/ins - HP.

4d2 100kHz through 1.8GHz - HP b.s.a.

4f. Pulse Analysis & TDR (Time Domain Reflectometry)

4f1 Reflectometer, down to ~10pS, distance 1 mm thro' 10 km - BT, HP.

4g. Attenuation, wideband/RF

4g1 Switchable and fixed, coaxial, 50/75Ω - Bradley, Hatfield, Marconi; HP, Narda, Tek , Weinschel.

4h. RF energy - Directionality

4h1 Powers Splitters/combiners, up to >2GHz, 3 & 4-way - HP, Narda, Weinschel.

4h2 Reflectometers, below 10MHz to >1GHz - HP.

4h3 SWR metering - Bird; RS/Welz.

See also **4k**.

4j1 Reception Test Aerials for Ambient RF/EMI & broadcast/signals

4j1a Omni. & various directional, lf to shf - BDR, R&S/MOD; Rohde & Schwartz; generic.

[quoted text next is in tinted box, black text on pastel tint]

> Varied aerial types, up to mini-Beveridge, can be evaluated in the free-field site of 30 acres extensible to over 1000. Tx/Rx test sites are also available at 1 to 25 miles .
>
> All b.s.a. & subject to relevant authorisations, viz. MOD/RAF.

4j2 Reception Test Sets for Ambient RF/EMI & signals.

4j2a 10kHz to 1GHz, am, cw, usb/lsb, fm, nbfm - Racal.

4j2b MF & HF, AM & CW general coverage receivers - Racal; Hammerlund; generic.

4j2c LF, MF & VHF - portable broadcast receivers: Bush, Ever-Ready, HMV, Marconi; Grundig.

4j2d LF, MF & VHF - fixed broadcast receivers: GEC, Pye.

4k - Microwave Apparatus

4k1 Crystal Detectors, <1GHz up to 11GHz - HP.
4k2 HPF & LPF, in-line, N - HP, Narda, Weinschel.
4k3 SWR metering, multi-scaled readout meter w/drive Amplifier - MOD.
4k4 Impedance analysers.
4k5 Sundry Microwave SWR & Z test accessories

4M Isolation & Protective

4m1 Transformer, 1:1 broadband ~70MHz to >1 GHz - Jenving/BDR.
4m2 Analyser protection w/in-line limiter <1.5v pk-pk c/w 150v DC blocking to >1GHz - BDR.

> Thinking back in history .. 1GHz = *one million kilocycles per second* (kc/s).
> This, the old fashioned form, pre-1970 or so, is felt to offer a clearer description of a readily appraisable, scaleably imaginable phenomena - that of rate, than is inferred by the use of 'Hertz', which is perfectly anodyne .. as to the stupendous rate of energy modulation, that a frequency such as 1GHz, really is.

5 - AC Power Laboratory (50, 60 & 400 Hz) V I

Equipment for the testing & evaluation of AC powered equipment , and also characterisation of the supply

Access All Areas

5a. Supply Access, adaptations & conversion - all BDR construct

5a1 Site Cee-form blue 240v 1ph 16A through 32 to 63A & vice-versa. Inter-series.
5a2 Site Cee-form, 3 phase red 415v 16A, etc, access. Also Lewden. Others b.s.a.
5a3 International, 13A to US 2 & 3 pin; to Schucko/Europlug; to Aus/NZ; to 5 & 15A BS round.
5a4 Equipment 13A/BS 1363 to IEC M/F, 6 & 10A.
5a5 Lighting power, lamp receptacle access to BC; BC↔ES. BC to 4mm access.
5a6 Differential-mode & Common-mode, signal injection & analyser reception jigs, for IEC & also 13A/BS1363 inter-adaptable to all above.

5b. RCD/RCBO Breakers - Deployable fault detection (BDR design/construct)

5b1 10mA portable, 10A/16A.
5b2/5 10mA portable, 32A/16A Cee/Cee, w/*Hornsey* Detector[§] system - Mead/BDR.
5b3 30mA portable, 100A
5b4 100mA portable, 63A
5b5 Deployable, in-line Hornsey Detector[§] - Mead/BDR .

[§] AC Supply trip or outage - local & remote-able Alarm, audible and visual warning that an RCD has been tripped.

5c. Supply stabilisation & assurance - *see* **9c5** ⇨

5d. AC Supply Monitoring & viewing

5d1 **Numeric**, voltage, > 4 digit, trms, automonitoring, bright across-room display - Datron/BDR.

5d2 **Needle**, **current & voltage** - avg & trms - Bradley, Sangamo-Weston (A).

5d3 **Wave** - I&V, to 1-4 MHz, balanced/diff. - Tek ; via access adaptor - BDR.

5d4 **Impulse detection** - voltage transients graded, to >10kV ; line current to 250A peak - BDR.

5d5 **E-field sensing** - generic. *Also available* for cable testing, using LF audio (see section **3k**) ⇨

5e. Power metering μW thro' kW

Amount of energy per unit time, rate at which supplied, or consumed/dissipated, a.k.a. *'work done'.*

5e1 **Low power** below 100 watts (below 0.4A rms @ 240v rms)

5e1a Dynanometer, 50Hz optimised, 100w to < 1 watt - Elliott (A).

5e1b Audio adapted, suits 50-60-400Hz, 50w to < 1mW - Marconi (A).

5e2 **High power**

5e2a Direct, needle 50Hz, in line, up to 10kW, via 13A (BS 1363) & 16/32A-Cee - Crompton, Elliott, Everett-Edgecumbe (A).

5e2b Above extensible, via multiplier CSRs (Shunts) where hardwiring permissible, and CTRs/clamp-ons (see section 2) - 11kV & 100/5 CTR = 1MVA, and 2500A @ 415v, to 1MW.

5e2c Numeric readout, high visibility large red LED, 10kW, extensible to 1MW - CRL.

5e2d Active/electronic, 10Hz to > 20kHz, up to 3kW - Feedback Instruments (A).

For Audio Power - see **3h**, **3p**.

5f. Power Factor (PF) metering - 50Hz

5f1 up to 20A , 240v, 1 phase, 270deg readout - Crompton (A).

5f2 up to 13A, 240v, 1 phase, digital readout - generic.

5f3 up to 6A, 415v, 3 phase, 270deg readout - Crompton (A).

Note: *All the above are generally unable to accurately compute* the PF of (modern day) non-linear loads.

5g. RCD (incl. RCBO)* Testing & validation

5g1 10mA thro' 500mA, with selectable preset durations - Seaward.

5g2 Fixed 30mA go/no go chkr, incl. N/E test - BDR.

* aka RCCB, GFi, current balance breaker

5h. Bond Testing

Down to 2 milli-ohms, up to 25 Amperes - Clare ; Kikusui (A). *See also* 1c3.

5j. Insulation

100v to 1kV, incl. 500v DC, to > 1000GΩ - AVO, Comark, Megger; GenRad. (A)

For Flash Testing - *see* **6c** ⇨

6. EHT / High Tension Laboratory

Putting your Left Hand away - EHT Lab work

"Notice for visitors. As a precaution before arrival please wear clothing with a left-hand-side pocket, preferably a back pocket. Since, the left hand of those working in a high voltage lab, needs to be safely kept in this pocket as soon as power is applied and also, while high energy may remain stored. This habit needs to apply whether you are left- or right-handed. To be clear, the same side one's heart is on. Most EHT practitioners have this instinctively hard-wired-in, by unpleasant experiences."

6a. Probes, extending Scope &/or DVM

6a1 DC & AC, up to 12kV, AC up to 100kHz; & up to 40kV at up to 10kHz - BDR; Fluke, Tek.

6a2 See 6b3 ⇨ line stick.

6b. Kilovolt meters

6b1 DC & AC (50Hz), Electrostatic, various, up to 19kV: Ferranti, Ernest-Turner (A).

6b2 DC, up to 30kV, bench, w/probe: Hunting H-Volt, Miles Hi-Volt (A).

6b3 AC & DC, Line Stick, ½ m stand-off, for high-energy supplies to 12kV - Ferranti (A).

6c. EHT test sources

6c1 - DC and 50Hz

6c1a Insulation & Flash

6c1a1 DC, to 12kV - AVO.
DC, to 30kV - Hunting/Miles HiVolt.
DC, to 90kV - HHV/BDR.

6c1a2 AC, to 6kV, 50Hz - AVO.

6c1b Ionisation - Test & Provocation

DC, up to 12kV - Airmec, AVO.
AC, 50/60Hz, up to 6kV - AVO.
Ionisation - detection, acoustic : see 12b1 ⇨

6c2 High Frequency

Variable 50Hz to 16kHz, variable 1 to 12kV - BDR.

6d. EHT Test Loads

6d1 low curr. for leakage cal. eg. 100µA, various, up to 90kV - BDR.

6d2 medium current, 1A, up to 11kV - MOD.

6e. EHT Switching

6e1 Vacuum relays, 11kV, 5A - Kilovac.

6e2 Sundry technologies, gaseous.

6f. EHT Storage All stored devices must be firmly shorted terminal-wise

6f1 Various, low nF up to 1µF & up to 30kV - Dubilier, Plessey, TCC, MOD.

6g EHT insulators (tension ends & suspension strings)

6g1 Ceramic deployable as 20 x 15kV or 2 x 150kV*.

6g2 Glass deployable as 2 x 75kV*.

**Voltage ratings are all-weather. Multiply x10 for dry use indoors.*

7. Calibration (Metrology Support)

7a. Voltage

7a1 DC

7a1a Standard cell group with 'multiple voting' - Tinsley/Sawyers.

7a1b Autocal standards - Datron.

7a2 AC

7a2a Cal. sources: AP-S1, Fluke, Gertsch, Harrison/HP, Holt.

7b. Current

7b1 DC

7b1a < 1µA to 10A, to 5.5 digits - Bradley.

7b2 AC - 50/60Hz

7b2a Cal source - Harrison, HP.

7b2b Ratio Transformers, 1:1 & 1:10 - Gertsch/Singer.

7c. Ohms

7c1 Aged stable standards, various low, med. & high ohms 10mΩ thro' 10MΩ, incl. 4 terminal & oil/air & fan/blast-cooled - as appropriate: Berco, Cropico, Sullivan, Sullivan & Griffiths, Tinsley.
See also HV section **6d** ↗

7d. Capacitance

7d1 Standards, aged, various low, med. & high values - Cambridge, Cropico, Muirhead, Pye, Sullivan.

7e. Inductance

7d1 Standards, aged, various low to med values - Cambridge, Cropico, Muirhead, Pye, Sullivan.

7f. Mutual Inductance

7f1 Standards, aged, various low to med values - Cambridge, Muirhead, Pye, Sullivan.
Consider also: Ratio transformers.

7g. Time

7g1 Time Mark generation, for oscilloscopy calibration - Tek.
7g2 Standards Counter, 9 digits to >1GHz, ovenised - Racal.
7g3 Secondary, aged 'voting' reference - HP.

8 - Component Characterisation Laboratory (CCL)

Mainly for active & non-linear devices and device parts thereof.

For resistance, capacitance & inductance, see **1c, 1d, 1e, 1f & 7d, 7e, 7f**

8a. Curve tracers

0 thro' 1.6kV, 1µA thro' 20A for BJTs, FETs, dios, Thy/Triac family & OPA - Tek.

8b. General semiconductor test sets

8b1 - BJT (small) & JFET - V_{br}, V_{fwd} @ I_{fwd}, I_{leak}, hfe, gono - AVO, BDR, Levell.

8c. Thyristor & Triac analysers & testers

8c1 - BDR, Peak ; Tek.

8d. Specific CC Test Sets

8d1 for LEDs - generic, Kemo.
8d2 for Bipolar power - thermal resistance - Sage.
8d3 for LATMOS V_{br} production screening - BDR.
8d4 for VMOS V_{gs} production screening - BDR.
8d5 for IC OPA parametric - Graeme/BDR.
8d6 for regulator test - Jung/BDR.
8d7 for battery Ampere-hour capacity - RCT.
8d8 for capacitor DA - MIL-STD/Jung/BDR.
8d9 for component distortion analysis to –140dBr down: Bateman/BDR.
8d10 for CCS test - Jung.

9 - Power Sources / Power Supplies

Auxiliary equipment used to power apparatus under test, or jigs.

9a. DC Voltage Sources

The following flavours are matrixed with functional divisions 9a1 thro' 9a3:

9a01 Regulated Voltage, dial-up digital (cal), 1v to 40v - Solartron. 10v to 1kV - Fluke.

9a02 Regulated Voltage, dial-up variable (uncal), 2mV up to 350v.

9a03 Unregulated Voltage, dial-up variable (uncal), 50mV to 2500v.

These 3 types are crossed with:

9a1 Lab bench supplies with V/I meters & C/Lim - Farnell, Thurlby, Solartron, Startronic.

9a2 Rack/system, small (<100W) Farnell, ITT.

9a3 Rack/system, large (>100W) Fluke, HP, Power Designs Inc, Kepco.

Note that there are also varying degrees of protection, from slight overloads to shorts, using different systems - re-entrant VI limiter, simple I limiter, wire fuses, thermal trips, magnetic breakers.

9b. DC Constant Current Sources (CCS, Forced current)

9b1 Steps set, 1µA thro' 10A, < 1v to 50v - Bradley.

9b2 Vernier Dial set, 1µA thro' 500mA, < 1v to 150v - HP.

9c1. AC Power - for operations requiring above 10kVA

9c1a 240v AC 1 phase, up to 25kVA, 50Hz - Central Networks, b.s.a.

9c1b 415v AC 3 phase, up to 75kVA, 50Hz - Central Networks, b.s.a.

9c1c 11kV/7kV 3ph, up to 1MVA - Central Networks, b.s.a.

9c1d Generators, b.s.a. available & installable to 1MVA, eg. 415/240v 3ph/3x1 ph; also 110/115v as 55-0-55v balanced. Also for 60Hz & 400Hz.

9c2 - Isolated 50Hz

9c2a 120v-0-120v 1:1 up to triple shielded, up to 5kVA - TEC, MOD, HP.

9c2b 115v:115v, some up to triple shielded, up to 5kVA - TEC, MOD, HP/Agilent.

9c2c 240v isolation, 0.5 thro' 3kVA with various op-modes: MOD/BDR, TEC/BDR.

9c2d 240v AC 1 phase, to 2kVA, isolated & psw Moto-gen - RN/MOD.

9c3 - Isolated & Variable Frequency

9c31 40Hz thro' 5kHz, Variable Frequency AC, 50VA to 5kVA - BDR, Derritron; California Insts, Elgar, Gertsch-Powertron.

9c4 - AC voltage adjustance

Variac transformers for levelling, setting, voltage range testing & investigation.

9c41 Up to 120A 1 phase & up to 40A 3 phase, multiple unit configs, thro' 50/60 & 400Hz. Voltage boost to 20% or 175%. Unique soft c/Lim to 1kW. Field portable, bench and trolley-mounted - Claude Lyons/BDR, Zenith/BDR; Powertrak/BDR.

9c5 - AC regulation

Assisting high-reliability AC-powered metrology, other data logging, & investigatory soak.
Also available for automated research into effects & behaviours.

9c5/1 CVTs, up to 3kVA, operable down to 30v, for 240v trms - Cetronic, Claude Lyons.

9c5/2 Auto/servo Variac, to 9kVA 3ph/3kVA 1ph, 0 to 415v/0-240v - Philips.

9c5/3 UPS, to 1kVA: Emerson; generic.

9c6 - Invertors (DC to AC)

Types intended for short term system back-up only

9c6a 24v to 120v, 500VA, spike/step wave.

9c6b 12v to 240v, 150/300VA, spike/step wave: generic.

9c6c 24v to 240v, below 3kVA, s/sw.

9c6d spare allocation

9c6e PSW invertors, 12v to 240v. b.s.a

9c6f PSW invertors, 24v to 240v. b.s.a

9c6g Other, & sundry allocations. *See also* **9c2d** above ↗

9d - Charging

9d1 14.25v charging **for 12v**, up to 25A cont, up to 250A cranking/jump - MOD.

9d2 28.5v charging **for 24v**, up to 12A & up to 500A, BJT-regulated - MOD/RAF.

9d3 58v charging **for 48v**, up to 6A, choke-regulated charge - MOD/RAF.

9d4 Sundry chargers for solid/sealed cells (NiMHy, NiCad, Lead Acid) - Yuasa, generic.
See also regulated lab supplies - **9a** above ↗

10. Thermometry

10a −100°c to +1500°c, numeric/digital and needle (A) for trends - Fluke ; Comark, Digitron.

10b Data logging: Chy.

10c Room temperature, space integrating, ultra-high resolution, chamber-stabilised - RKBI/BDR.

11. Optical, Photographic & Repro

11a Colour & mono/greyscale production, reversal, flip, colour shift, background erasure - Xerox.

11b Photographic recording instruments, 35mm thro' digital: Canon, Minolta, Vivitar.

11c1 Backlit viewers (slide box).

11c2 35mm projection theatre, b.s.a.

11d Densitometers, colour & greyscale - *adapted as LED analyser & for metallurgy* - MOD/RAF.

11e Microfiche and micro-surface reading - MOD.

11f Microscopy: Lomo.

12. Sundry Operations Equipment

12a1 Torches, Damage Control & Task, halogen + LED - Crompton/BUWEPS/BDR.

12a2 Torches, LED, head - generic.

12a3 Torches, LED, magnetic clamp - generic.

12a4 Torches, LED, sub-miniature gooseneck (investigatory) - generic.

12b1 Mirrors, w/angle-poise & extensible - generic.

12c1 Stethoscopy - eg. ionisation inceptive detection to ~100kV, also magnetostriction detection. See **6c1c** ↗

12d1 Absolute pressure: Wallace & Tiernan.

APPENDIX

At BDR, equipment with DoMs ranging from around 1925 through until today's latest, is in productive, active use. Using widely varied instruments, often creatively ('creative abuse') has solved *many* problems *and* helped to make *many* discoveries, for our clients - those who manufacture - make - produce - market and distribute electronic products, devices, units and systems. Multiple Lab spaces/benches are assignable across multiple building and spaces ranging up to a multi-acre, extensible b.s.a.

It is firmly established with the niche capacity to observe equipment competence across 70 years or more, that lab equipped with solely modern test equipment (post 1995) would be likely to 'sail past' many operational subtleties in electronic/electrical systems & circuits, that are *only* or, better, mapped or appraised by older metrology methods & technologies. Spectrum analysis/surveillance is one example - intrinsically realtime analogue remains more realtime than digital, which has latency built-in. Needle meters' capacity to shows trends & fluctuances clearly, is another.

Some of the equipments' precursor-owners, & former operators -

Many of the names & organisations listed below are now filed under history & Industrial Archaeology.
All locations UK, or UK sovereign base, even where a US company name.

AECC
Agilent Technologies
Air Ministry (UK)
Aldermaston
AWRE
BA Bristol (Filton)
BAC
BAC Guided Weapons
BAC (Operating) - Stevenage
BA Dynamics, Stevenage
BA - Stevenage
BA - Stevenage (Bristol Division)
BAE
BOAC
British Aerospace
British Aircraft Corporation
British Airways
British Cellophane
British Telecom
BT - Fulcrum
BUWEPS*
CAA
Coulport (RN)
Culham
Cyprus Calibration Centre
Devonport
DG-DQA
EEV-Marconi
EMEB
EEV/English Electric Valve
Faslane Calibration
GEC
Hawker
Hawker-Siddeley
Hewlett Packard (UK)
IBM
ITT (Foots Cray)
ITT - Harlow
ITT - Power Division
Lucas-Bradley
Marconi
Marconi Electronic Devices
Marham (RAF)
Mark Angelo Recording
Martlesham (BT)
Marconi-MEDL
Midland Electricity Board
MOD
MOD (N)
MOD (SSCP)
Odiham (RAF)
Portsmouth (RN)
RAF
Rank-Cintel
Redwood Electronics Ltd
REME
RNAD
RNSD
Royal Navy
Royal Ordnance
Sealand
STC
STC power components
Vodaphone
Woolwich DQA

Note: *Bristol Aero Co. (Filton) merged w/Armstrong-Siddley (1958) becoming part of British Aircraft Corporation (BAC) in 1960. Research at Bristol lead to BAC Concorde (1972-2002).*

Age Profile - DOM (Date of Manufacture)

Includes internal productions.

1925-1934	1%	
1935-1944	1%	
1945-1954	2%	
1955-1964	11%	Solartron AS14*xx* Bench PSU and HP 140 (both 1963) remain top class designs.
1965-1974	20%	Some equipment created in this decade has not been equalled.
1975-1984	26%	Analogue equipment quality reached a peak. Also, digitally-aided analogue.
1985-1994	21%	Equipment quality & repairability began to degrade steeply, after this period.
1995-2004	12%	Equipment quality is now degraded by LC screens, SMT, irreplaceable special ICs.
2005-2011	6%	Equipment quality degraded by excessive 1st world regulation, decreasingly small surface mounted parts (almost irrepairable), and not being made in UK, made to never be serviced, and evidently, being designed by disconnected people who will never actually have to use the equipment - or pay for it & its upkeep.

Profile by Nationality of manufacture

UK*	54% - over 100 makers.
US	40% - dominated by Hewlett-Packard, then Tektronix, then Fluke, Keithley.
German	2% - mainly Rodhe & Schwartz.
Dutch	1% - mainly Philips.
French	1%
Japanese	1%
Swedish	<1%
Other	<1%

** Includes internal productions.*

Note: The listings generally give makers in the order UK ; US ; other .

Some sources of Inspiration

~ Public ~
www.slack.com - Dave DiGiacomo
Tektronix instrument museums
Hewlett Packard instrument museums
Other test equipment collections
ERA Laboratories
Jim Williams - RIP
Robert Pease
Walt Jung

– Private –
Bruce Hofer
Craig Sawyers
Cyril Bateman
Norman Palmer
Jerry Mead
Harry Day
EV lab

FOR INDICATION ONLY

Test Invalid if LED lit ■✹■

E&OE. All information is indicative & provisional