AccessionIndex: TCD-SCSS-T.20160323.001
Accession Date: 23-Mar-2016
Accession By: Mike Nowlan, Tom Kearney, Dr.Brian Coghlan, Ken Gordon
Object name: Networking and the Internet
Vintage: c.1991
Synopsis: Networking hardware and the arrival of the Internet in Ireland.

Description:
The email below is by Mike Nowlan, then Systems Manager for the Department of Computer Science, Trinity College Dublin, who was closely involved in the evolution of networking in Ireland.

-----Original Message-----
From: Michael Nowlan [mailto:michael@ashe]
Sent: Wednesday 19 June 1991 12:07
To: stafpgrad
Subject: Testing of Internet connectivity is now possible

As many of you have found out, TCD was connected to the Internet on Monday afternoon. This service is now available for testing on both Swift and Ashe.

No gaurantees of reliable service are offered at present, it is quite likely that the line with go down at no notice.

If you plan to ftp files, it is suggested that you look on the machine mcsun.eu.net before trying systems across the Atlantic.

--
Michael Nowlan..

This is a momentous email. It announces the arrival of the Internet in Ireland.

The Internet is constructed from both hardware and software, and in both domains had a long and interesting gestation. Elsewhere in this catalog are examples of networking technology that both preceded and followed the arrival of Internet.

The first machine installed in TCD, an IBM 1620 installed in 1962, see elsewhere in this catalog, was entirely standalone, with no networking at all. Similarly for the next machine, an IBM 1130, also see elsewhere in this catalog.

The third machine, an IBM 360/44 installed in 1969, was the first time-sharing system in Ireland, with *local* IBM 2260 user terminals directly connected via multicore or coax cables to an IBM 2848 controller, again see elsewhere in this catalog.

The first machines in TCD to be linked (point-to-point networked) were this third machine and the fourth, a Burroughs 1714, see elsewhere in this catalog. This was done by Peter Chadwick as his MSc project. The experimental hardware constructed to do this survives, again see elsewhere in this collection.

The next step in networking was the evolution of *remote* time sharing of machines amongst remote users over an ad-hoc on-demand star network created when users connected via acoustic data couplers to their telephone landlines into acoustic modems to serial line interfaces on the DEC-20 installed in TCD in 1977. Some examples of this modem technology survive in the collection.

This time-sharing to networking users was continued with the departmental VAX 11/780, which was first installed in 1979 with 24 serial lines and later upgraded to 80 serial lines, see the VAX 11/780 description in this catalog.

During the early years (1979-1990) in which the VAX 11/780 served the department, three strands of networking activity began. The first was the proposal to set up an Irish Universities Network (*IUN*) in 1979, to link machines in TCD, UCD and the National Board of Science and Technology (*NBST*), first implemented in rather flaky experimental form in 1982.

Secondly, before the arrival of Internet, the department adopted a variety of strategies to introduce and support email. This early email system was a collection of protocols and services that attempted to maximise the connectivity whilst minimising costs. It probably all started with the Department's use of email on its VAX-11/780 using *VMSmail*; this was good for its time and mailing lists were set up early on; the central list for members of the department was the fondly-remembered *StaffPgrad*, while other more granular lists were set up for various classes and groups.

The VAX-11/780 ran DECnet locally, and was used internally in the department to connect its local machines. Because it was "built in" it made transferring files easy, like a native network/filesystem. It is believed to have also connected other local TCD DECnet machines, such as those in the TCD Computer Laboratory as well as those in the TCD Dept.Microelectronics (MEE).

In 1983 HEAnet was established, using X.25 to interconnect single machines in each college. This was at a time when serial ports were expensive and serial line switching was done using a Gandalf switch (later local X.25 switches and CAMTEC packet assemblers/disassemblers, i.e. PADs, were installed to construct internal X.25 college networks with terminals attached directly to the PADs). The department then began X.25 services to HEAnet on its VAX-11/780 (*csvax1.cs.tcd.ie*), as well as services over X.25 to other universities in Ireland using a package called *PSI*, and the UK pseudo-ISO software called the *Coloured Books* that integrated the universities in Ireland and the UK. It was better than nothing and it mostly worked.

At around that time, Dr.Tim Murphy from the TCD Maths Department modified the *uucp* protocol (UNIX-to-UNIX-copy, which was supported from 1979 by UNIX Versions 7 and later) to support 7-bit transport over the X.25 network. The Dept. Computer Science then used this to host its own Internet protocol (IP) network with a few machines running UNIX, one (*relay.cs.tcd.ie*) acting as a gateway to the *uucp* network. Email was sent on a store-and-forward basis through EUnet in Europe, using a very flexible package called *MMDF* (Multichannel Mail Distribution Facility) that could transform addresses and route down different channels to many destinations.

This allowed a UNIX machine in the department to be connected to the worldwide uucp network, which provided gateways to the Arpanet and many other networks such as the high-energy physics DECnet. Initially the department talked to the Irish node but eventually migrated to the University of Canterbury before taking over the Irish node at a later stage. The immediate benefits were provision of email, and a wider and deeper connection to research of all kinds elsewhere in the world.

On the department's VAX-11/780 (*csvax1.cs.tcd.ie*), a package called *PMDF* (Pascal Memo Distribution Facility) mirrored *MMDF* on the UNIX system. PMDF and MMDF collected all email and routed the messages in an appropriate manner, all without any knowledge of the user. The system required a reasonable degree of management as many of the connections were unreliable. Eventually this system became a gateway for all universities in Ireland.

The third strand was the research into local and wide area networking, mostly on the development of packet switching networks. For local area networking (*LAN*), in 1980 the department installed wiring for both *Cambridge Ring* and the first generation 3Mbps *Ethernet*. Hardware for the former is lost, but examples for the latter survive in the collection. Wiring was also installed for Apple's *LocalTalk*, for which hardware also is in the collection. Wide area networking (*WAN*) research concentrated on X.25, with involvement in EURONET, set up in 1979, and Diane, the information retrieval system built above it.

The 3Mbps Ethernet research hardware predated the official release of (10Mbps) Ethernet in 1980. Both used a thick coaxial cable (*thickwire*, or officially *10BASE5*) with an electrical tap (an AUP) into the common shared cable for each user, where if user packets collided, then a specific *collision avoidance* methodology (based on the Hawaiian *Aloha* radio network) kicked in to reschedule transmission of the packets such that they did not collide. 10Mbps Ethernet soon gained favour for LANs over Cambridge Ring technology.

In 1984 the department's Distributed Systems Group (*DSG*), who did most of its networking research, received sizeable funding from *ESPRIT* (European Strategic Research Program in Information Technology) for the *Commandos* distributed operating systems project. This eventually led to the setting up of *Iona Technologies* whose *CORBA* middleware for linking incompatible machines was very successful and installed in many countries.

The necessity for cumbersome thickwire installations eventually prompted an evolution of Ethernet away from a common cable (*serial bus*) to a star network of point-to-point connections per user over thin coaxial cables (known as *thinwire*, or *cheapernet*, or *10BASE2*), with Ethernet switches to direct packets between users and machines. Thinwire Ethernet, introduced in the mid-1980s, rapidly predominated. A number of machines that include thinwire Ethernet interfaces survive in this collection, as well as thinwire Ethernet interface controller boards, switches, concentrators, repeaters, etc.

In 1990 the 10Mbps coaxial cable with its BNC connectors was replaced by the first version of now familiar more flexible multi-stranded cables with RJ-45 connectors. This first version was called *10BASE-T*. The collection includes example hardware.

In 1991 the *European Unix Users Group (EUUG)* and its loose confederation of sites, *EUnet*, was formalised by the creation of a Netherlands company, *EUnet BV*, to run its central network as a commercial service, with Michael Nowlan (departmental systems manager, who sent the email above) as its chairman. EUnet subsequently became Europe's largest internet service provider, offering access through partner organisations in a dozen countries. Departmental systems support work in the networks area, especially in conjunction with the *EUUG*, led to the formation of a campus company, *IEUNET*, which was the first internet service provider in Ireland. Its directors were Prof.J.G.Byrne (who founded both the department and this collection), Michael Nowlan and Cormac Callanan (a lecturer in DIT College of Marketing and Design).

ARPANET was formally decommissioned on 28-Feb-1990. The Internet was introduced into Ireland in Jun-1991 with the email above. This was a seminal event for Ireland. The IP connection was a 19.2Kbps circuit from the department via the University of Kent at Canterbury to Amsterdam over circuits provided by Telecom Eireann, British Telecom and Mercury Communications in the UK (with all the problems of dealing with three phone companies and their regulations and type approval on equipment), and with costs shared by IEUNET and the TCD Computer Laboratory. Installations were made in early June and first end-to-end connections were made on 17-Jun-1991. Subsequently Ireland and the world have become highly connected via wired, wireless and optical connections to the Internet. One of the more unusual variations that survives in this collection is the packet radio hardware that Prof.Foster used to exchange email with Africa via satellite.

Fast Ethernet or *100BASE-T* (100Mbps) was introduced in 1995. Numerous machines that include Fast Ethernet interfaces survive in this collection, as well as Fast Ethernet interface controller boards, switches, etc.

In 1997 IEUNET was bought by ESAT Telecom for ^{IR}£3.2m.

The next evolution was 1Gbps Ethernet (*1Ge* or *1000BASE-T*), introduced in 1999, which required boosting of the high-frequency components of the Ethernet signals to compensate for cable attenuation at those frequencies. Again machines that include 1Ge interfaces survive in this collection, as well as controller boards and switches.

The current evolution is 10Gbps Ethernet (*10Ge*), introduced in 2002. Collision avoidance was finally dropped for 10Ge. Again machines that include 10Ge interfaces survive in this collection, as well as controller boards and switches. Most 10Ge connections are over optical fibre, but an alternative copper twinax cable (CX4) was introduced in 2004, examples of which are in the collection. The 10Ge hardware in the collection (some still in use but marked for collection) was from the Grid-Ireland OpsCentre, which had a 10Ge backbone to its clusters and datastores, as well as dual-redundant 10Ge connections via the TCD front-end switch to the HEAnet 10Gbps *ROADM* multi-wavelength optical networking deployed in Oct-2008,

Wireless local-area networking (*WLAN*) takes a number of forms, now dominated by *WiFi* using 2.4GHz and 5GHz radio bands, based on a wide variety of patents, such as those by astronomers at the CSIRO in Australia. 2Mbps WLAN was introduced in

1997, expanded to 11Mbps to 54Mbps variations in 1999 (along with the term *WiFi*), to 150Mbps in 2009, and to 867Mbps in 2013. It is now one of the major mediums local networking and for access to the Internet, and representative hardware is in the collection.

The rise of parallel computing was initially based on interconnecting groups of machines with either commodity Ethernet in loosely-coupled Beowulf clusters or with purpose-designed high-speed interconnects in tightly-coupled parallel machines. For the former see the cluster descriptions in this catalog. For the latter, over time there was an evolution of standards-based high-speed interconnects, and several examples of these survive in the collection, for example, the multi-Gbps SCI (including over parallel optical fibre), Fibrechannel and Infiniband interconnects.

The collection includes many books on networking, and also many examples of specific networking software, such as DECnet, TCP/IP and Kermit, and significant operating systems that fostered the networking paradigm, especially the various forms of UNIX like Berkeley BSD, SUNOS, System-V, ULTRIX, OSF and Mach.

First-Generation 3Mbps Ethernet

Ethernet was invented at Xerox PARC in 1973 by Bob Metcalf and others, based on the Hawiian ALOHA radio network, and was patented by Xerox in 1974, then used in Xerox PARC from 1975. The name came from the *luminiferous Ether* that was at one time thought to be the medium through which electromagnetic waves propagate.

Ethernet was 1-persistent, and used a distributed arbitration mechanism developed at PARC known as *Carrier Sense Multiple Access with Collision Detect* (CSMA-CD) with *Binary Exponential Backoff* (BEB). The data rate was 3Mbps, a “convenient data transfer rate [...] well below that of the computer’s path to main memory”, so packets would not need to be buffered in Ethernet interfaces. For first-generation 3Mbps Ethernet boards see elsewhere in this catalog.

Ethernet employed Manchester encoding on a 9.5mm diameter baseband coaxial CATV cable (*thickwire* cable). A hole was punched through the coax cladding and the outer conductor so a connection (‘tap’) could be made to the inner conductor. The two cable ends (branching was not allowed) were impedance terminated to minimise reflections.

Fig.2 shows a photograph of the 3Mbps Ethernet black coaxial cabling as installed around the Dept.Computer Science, TCD.

Ethernet receiving stations monitored (sensed) the 'ether', i.e. all stations saw all packets. Their receiving hardware reduced the processing burden by ignoring packets that were not addressed to them or the broadcast address.

Ethernet stations wishing to transmit also monitored (sensed) the 'ether' for transmissions and when there were none they broadcast transmitted a frame, and monitored their own transmission. If interference (‘collision’) was detected, the transmission was terminated immediately and a jam signal was sent for 32 bit times, and the stations incremented a local counter K (initially 0) and randomly selected a backoff interval using a uniform distribution over (L = 2*K), and then retransmitted.

Thus the value of L was doubled locally for each sending station. ALOHA was shown to be unstable when p > 1/n, so 3Mbps Ethernet permitted only up to 1024 stations, where backoff continued until K = 10, L = 1024, and p = 1/1024. Normally K could be incremented up to 10, but BEB was set for 16 retries, after which the station gave up trying to send the frame.

Collisions were detected very quickly and the colliding transmissions were broken off, and did not waste much time. CSMA/CD 3Mbps Ethernet performance under load was quite good. In their paper from 1976 describing the experimental 3Mbps Ethernet, Bob Metcalfe and David Boggs showed that for packets of 500 bytes and larger, more than 95 percent of the network capacity was used for successful transmissions, even if 256 computers all continuously had data to transmit.

Subsequent Evolution of Ethernet

In the late 1970s, Xerox joined with Digital and Intel to form the DIX consortium, which created a multi-vendor 10Mbps DIX specification (ultimately DIX 2.0). Then the Institute of Electrical and Electronics Engineers (IEEE) produced the IEEE-802.3 networking standard. DIX 2.0 and IEEE 802.3 were fully compatible, excepting in the layout and meaning of the Ethernet header fields. Network branching was allowed using repeaters.

As discussed above, the next evolution, *thinwire* coax, replaced the taps with BNC T-connectors. Eventually by 1990 a further evolution allowed unshielded twisted pair (UTP) cables made of four pairs of thin twisted wires with RJ45 plastic connectors. Data rates have subsequently increased substantially, from 10Mbps to 100Mbps, 1Gbps, and 10Gbps.

In connectivity, the world has come a long way since the first telegraphs (see Fig.20).

Irish Internet 25th Anniversary Event

On the 15th June, 2016, the 25th anniversary of the arrival of the Internet in Ireland was celebrated by an event hosted by Google at The Foundry at Google, Gordon House, Barrow Street, Dublin 4, see Figs.21-24 below. On the 17th June, 2016 (the actual 25th anniversary), Mike Nowlan was interviewed on the RTE radio programme *Morning Ireland*; an electronic recording of this is preserved in the associated folder in this catalog, courtesy RTE.

Acknowledgements

Many thanks to Mike Nowlan for permission to republish the email above, to Mike Nowlan, Tom Kearney and Brian Coghlan for photographs, and to Tom Kearney, Brian Coghlan and Ken Gordon for the networking hardware, some of which was recovered from wiring closets and underfloor spaces after having lain there for over 30 years.

Accession Index	Object and Identification
TCD-SCSS-T.20160323.001.01	DEC H4000 Thickwire to AUI transceiver mated to Thickwire adapter. Model: H4000 Rev.D1, S/N: KL 16381
TCD-SCSS-T.20160323.001.02	Dlink DE-850 Thickwire Ethernet transceiver. S/N: ETA2004816
TCD-SCSS-T.20160323.001.03	BICC Thickwire adapter. S/N: ???
TCD-SCSS-T.20160323.001.04	BICC ISOLAN 1110 Ethernet transceiver mated to BICC Thickwire adapter. ISOLAN 1110 S/N: 4/012/047
TCD-SCSS-T.20160323.001.05	DEC H4005 Ethernet transceiver mated to BICC Thickwire adapter. H4005 Model: 70-22781-01 Rev.1B2, S/N: SA90401359
TCD-SCSS-T.20160323.001.06	Klever Thickwire to AUI transceiver mated to Thickwire adapter. P/N: ET-10C1B, S/N: 86006310
TCD-SCSS-T.20160323.001.07	Pirelli FOCOM Thinwire to AUI transceiver. P/N:522124A Mod 1/A12 , S/N: 00142201
TCD-SCSS-T.20160323.001.08	Apple Ethernet Thinwire Coax Transceiver M0329. P/N: ET-10C1B, S/N: 86006310
TCD-SCSS-T.20160323.001.09	Lantronix LTX-2 10BASE-T to AUI transceiver. S/N: 11258255
TCD-SCSS-T.20160323.001.10	Lantronix LTX-C 10BASE-T to AUI tranceiver. S/N: 14007296
TCD-SCSS-T.20160323.001.11	Lantronix LTX-C 10BASE-T to AUI transceiver S/N: 14007281
TCD-SCSS-T.20160323.001.12	CentreCOM MX40F/ST 10BASE-FL fibre optic to AUI transceiver. Model: AT-MX26F, S/N: F5W27062F
TCD-SCSS-T.20160323.001.13	Asante FriendlyNet 10BASE-T to Macintosh AAUI transceiver. (AAUI is Apple Attachment Unit Interface for Ethernet) S/N: 54630406
TCD-SCSS-V.20141212.001	Diagram for pre-production SUN-1 Workstation 3Mbps Ethernet wiring at TCD. See Fig.1 Marking: Handwriting appears to be that of Dr.Neville Harris.

The diagram of the 3Mbps Ethernet wiring is properly part of the Literature category of this catalog, but is listed here for convenience.

References:

1. Wikipedia: http://www.wikipedia.org/.

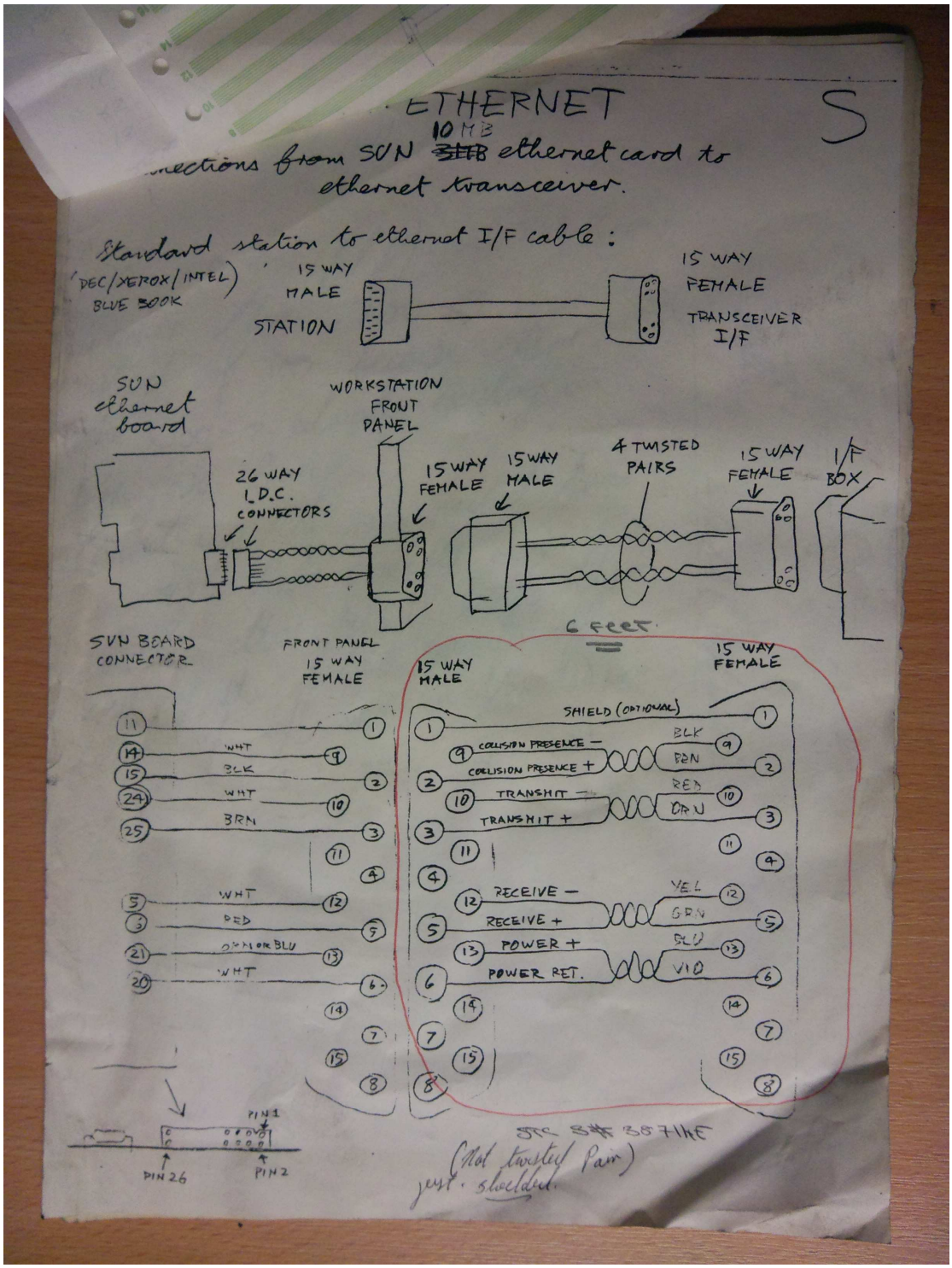

Figure 1: Pre-production SUN-1 Workstation 3Mbps Ethernet wiring at TCD
Note update from 3Mbps to 10Mbps Ethernet
(handwriting appears to be that of Dr.Neville Harris)

Figure 2: 3Mbps Ethernet cabling at Dept.Computer Science, TCD
Photo courtesy Mike Nowlan

Figure 3: DEC H4000 first-generation Thickwire to AUI transceiver coupled to Thickwire coaxial cable
Note light-gray Thickwire adapter mated with black Ethernet transceiver, and silver terminators at cable ends
H4000 Rev.D1, S/N: KL 16381

Figure 4: Dlink DE-850 Thickwire Ethernet transceiver separated from Thickwire adapter S/N: ETA2004816

Figure 5: BICC Thickwire adapter, separated from Ethernet transceiver
'Caution' label covers contacts for mating with transceiver

Figure 6: BICC Thickwire adapter mated to BICC ISOLAN 1110 Ethernet transceiver ISOLAN 1110 S/N: 4/012/047

Figure 7: BICC Thickwire adapter mated to DEC H4005 Ethernet transceiver
H4005 Model: 70-22781-01 Rev.1B2, S/N: SA90401359

Figure 8: Klever Thickwire to AUI transceiver
P/N: ET-10C1B, S/N: 86006310

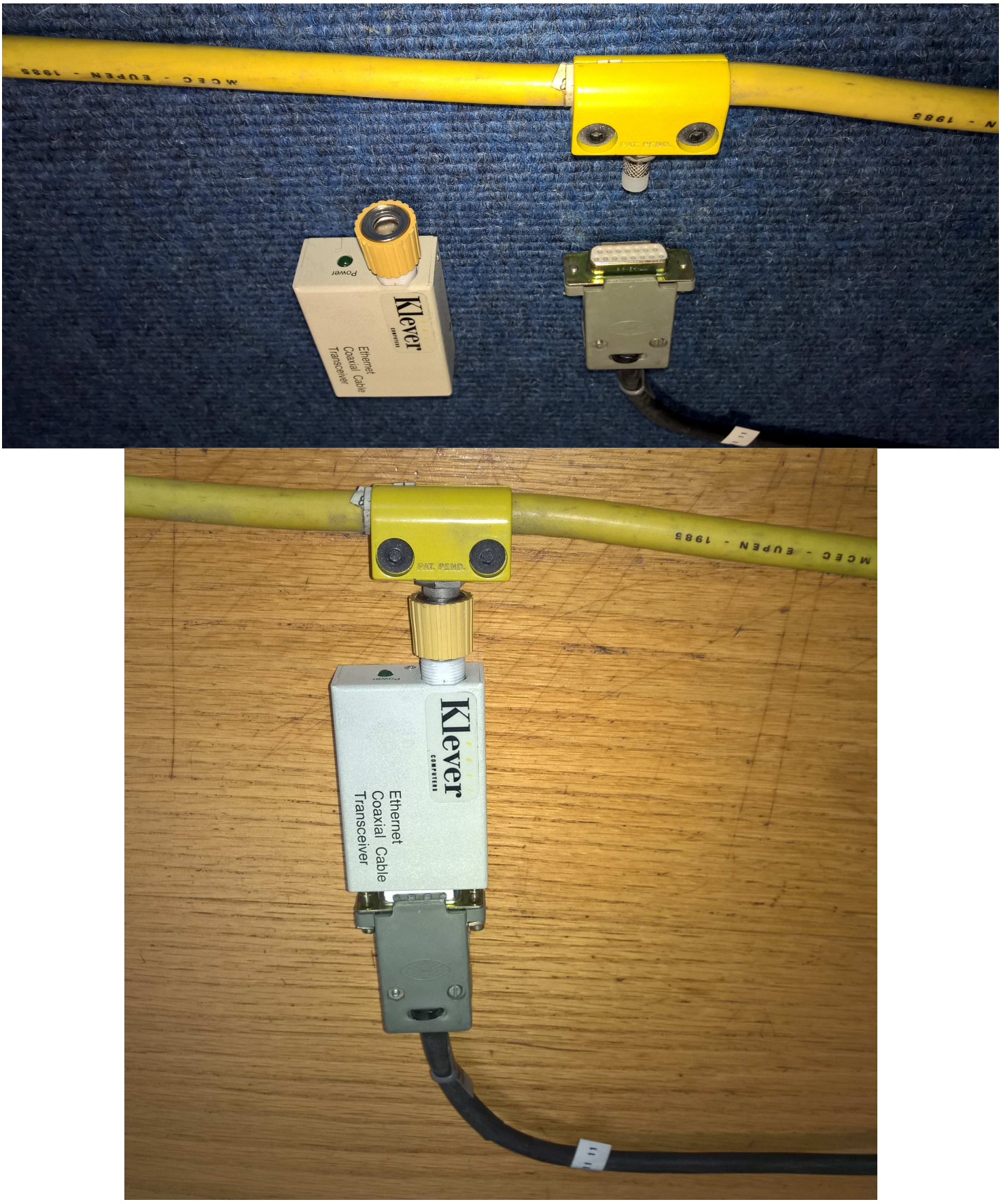

Figure 9: Klever Thickwire to AUI transceiver before and after attachment to 10BASE5 Ethernet coax cable (Klever transceiver mated to Thickwire adapter)

Figure 10: Pirelli FOCOM Thinwire to AUI transceiver
P/N:522124A Mod 1/A12 , S/N: 00142201

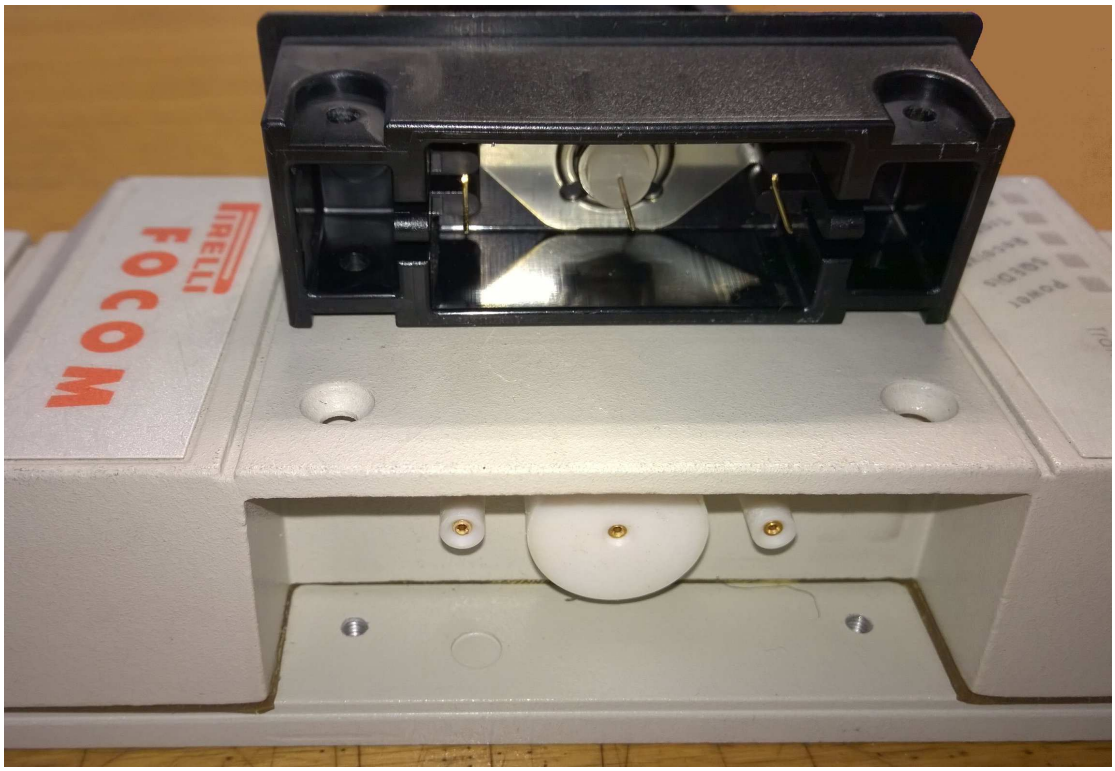

Figure 11: Pirelli FOCOM Thinwire to AUI transceiver adapter
(the design appears to allow for alternative thickwire adapters)

Figure 12: Apple Ethernet Thinwire Coax Transceiver M0329

Figure 13: Lantronix LTX-2 Thinwire to AUI transceiver
S/N: 11258255

Figure 14: Lantronix LTX-C 10BASE-T to AUI transceiver
S/N: 14007296

Figure 15: Lantronix LTX-C 10BASE-T to AUI transceiver
S/N: 14007281

Figure 16: Lantronix LTX-C 10BASE-T and LTX-2 Thinwire to AUI transceivers coupled together to link 10BASE-T to Thinwire

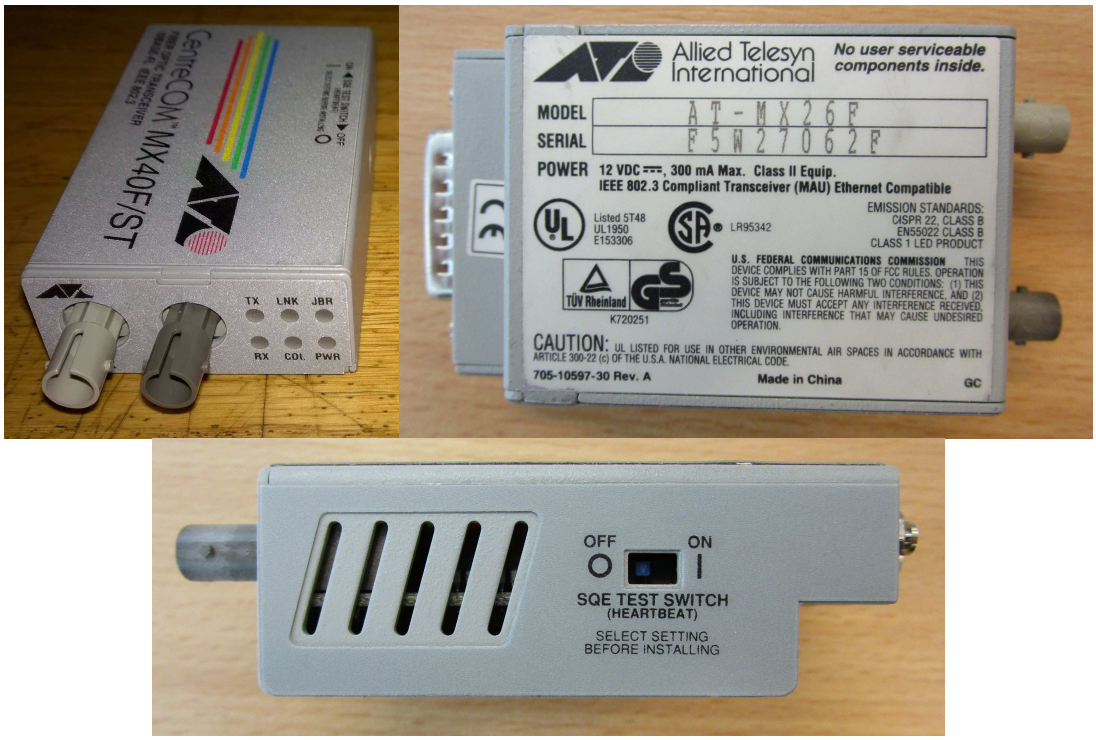

Figure 17: CentreCOM MX40F/ST 10BASE-FL fibre optic to AUI transceiver Model: AT-MX26F, S/N: F5W27062F

Figure 18: Lantronix LTX-C 10BASE-T and CentreCOM MX40F/ST 10BASE-FL to AUI transceivers coupled together to link 10BASE-T to optical fibre

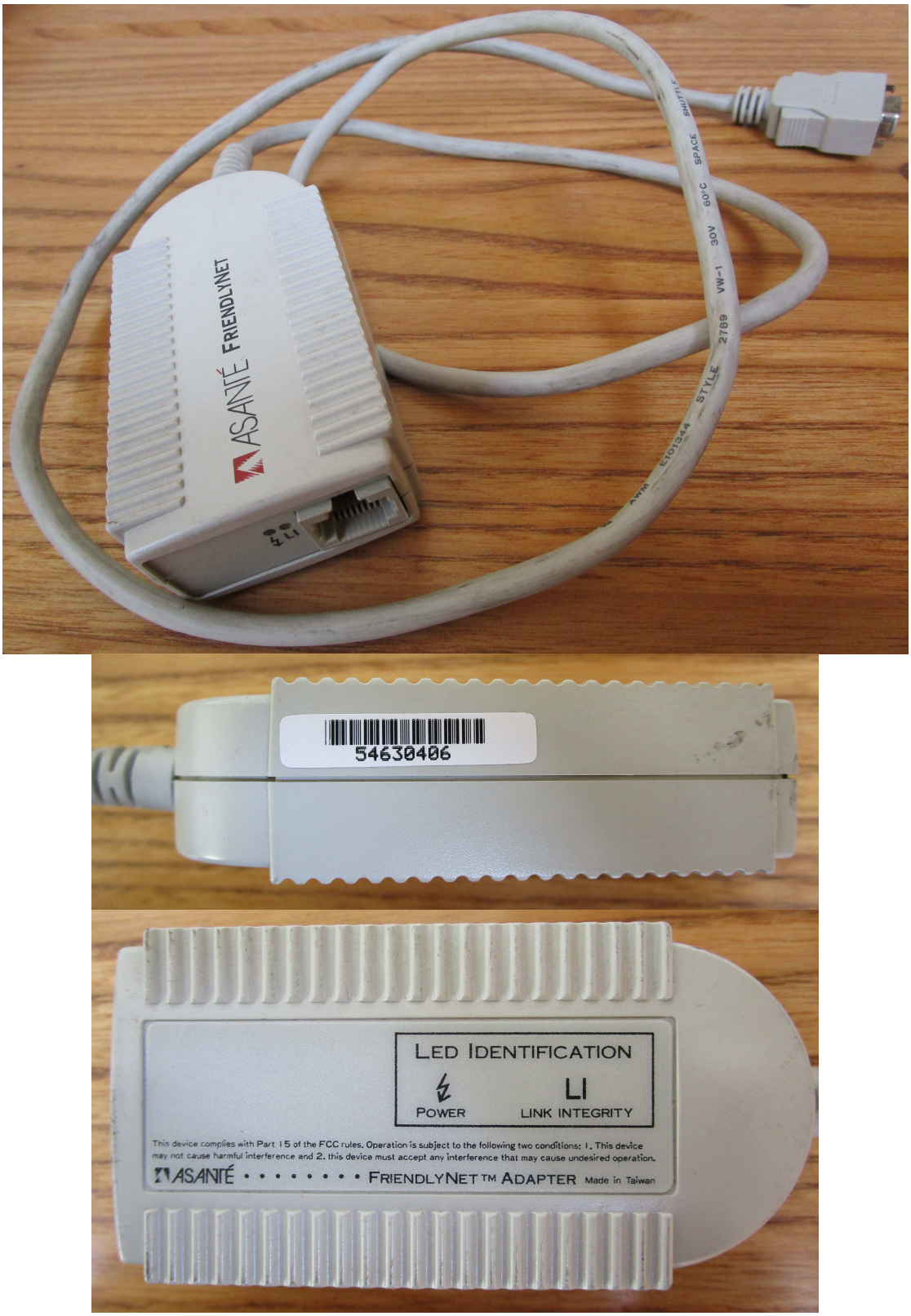

Figure 19: Asante FriendlyNet 10BASE-T to Macintosh AAUI transceiver (AAUI is Apple Attachment Unit Interface for Ethernet)
S/N: 54630406

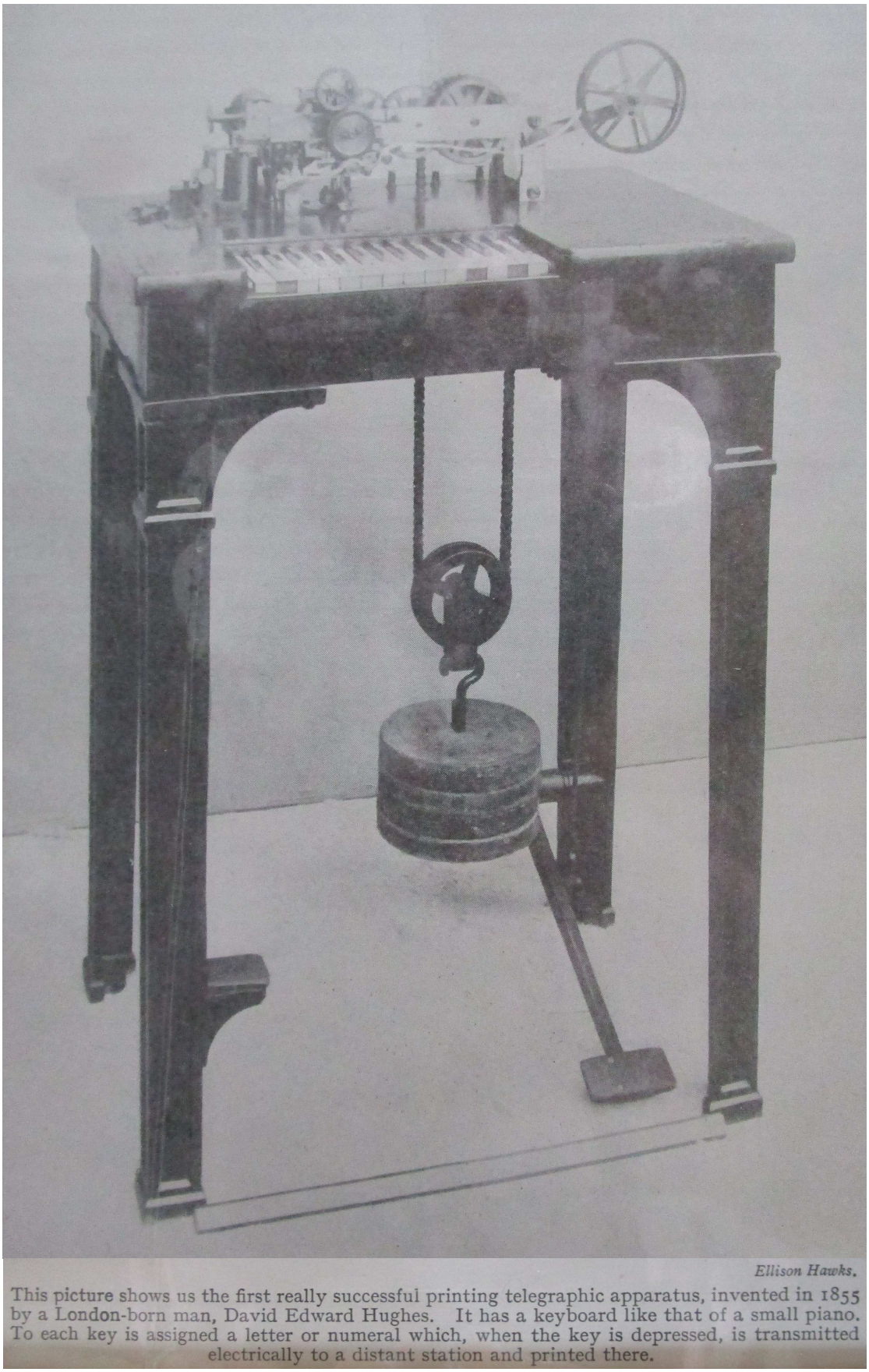

Figure 20: Printing Telegraph, c.1855
(framed photograph in the collection)

Figure 21: Irish Internet 25th Anniversary Event, compere Brian Trench

Figure 22: Irish Internet 25th Anniversary Event, Mike Nowlan
Mike sent the email that announced the arrival of the Internet in Ireland

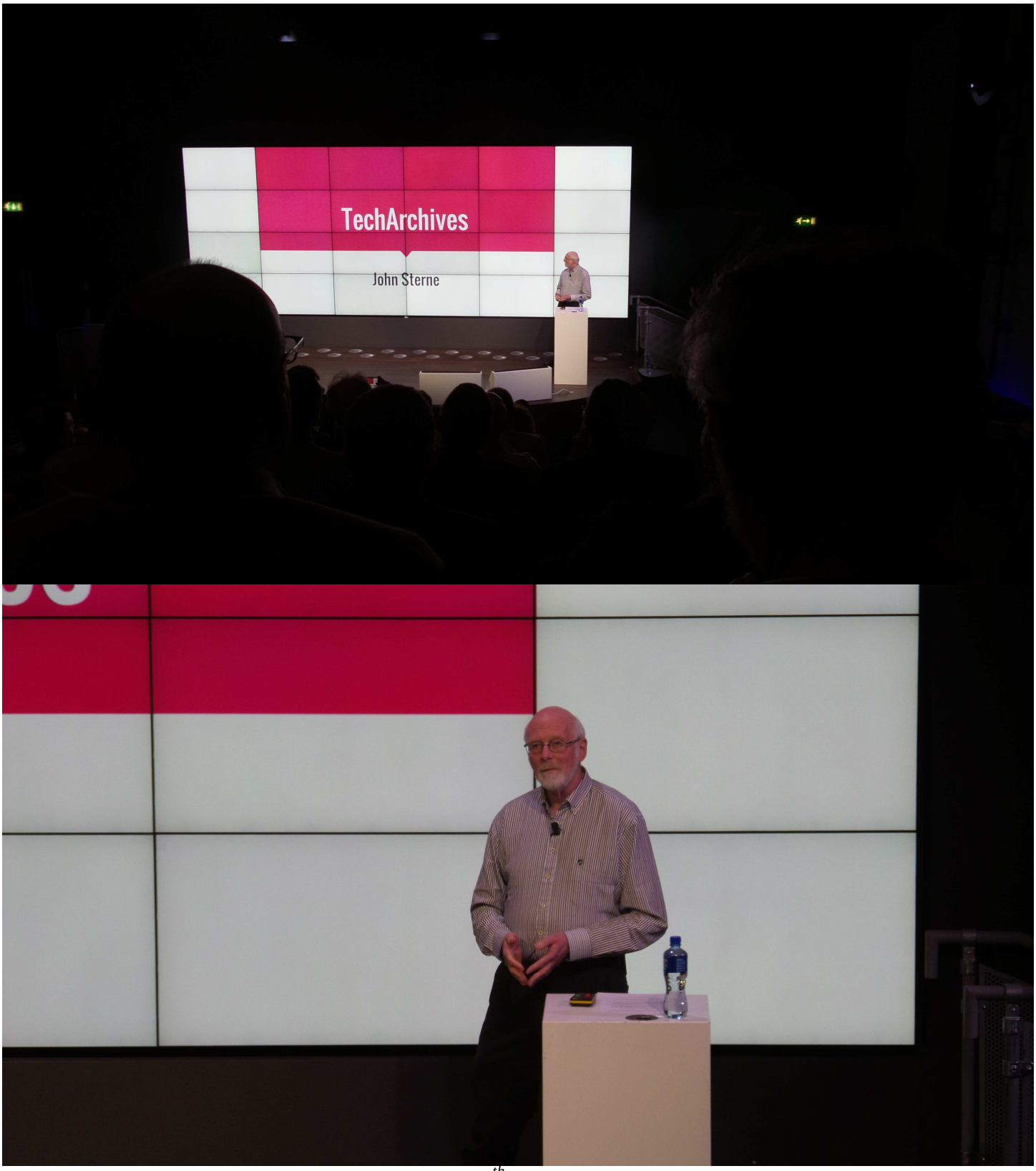

Figure 23: Irish Internet 25th Anniversary Event, John Sterne
John announced that www.techarchives.irish was now online

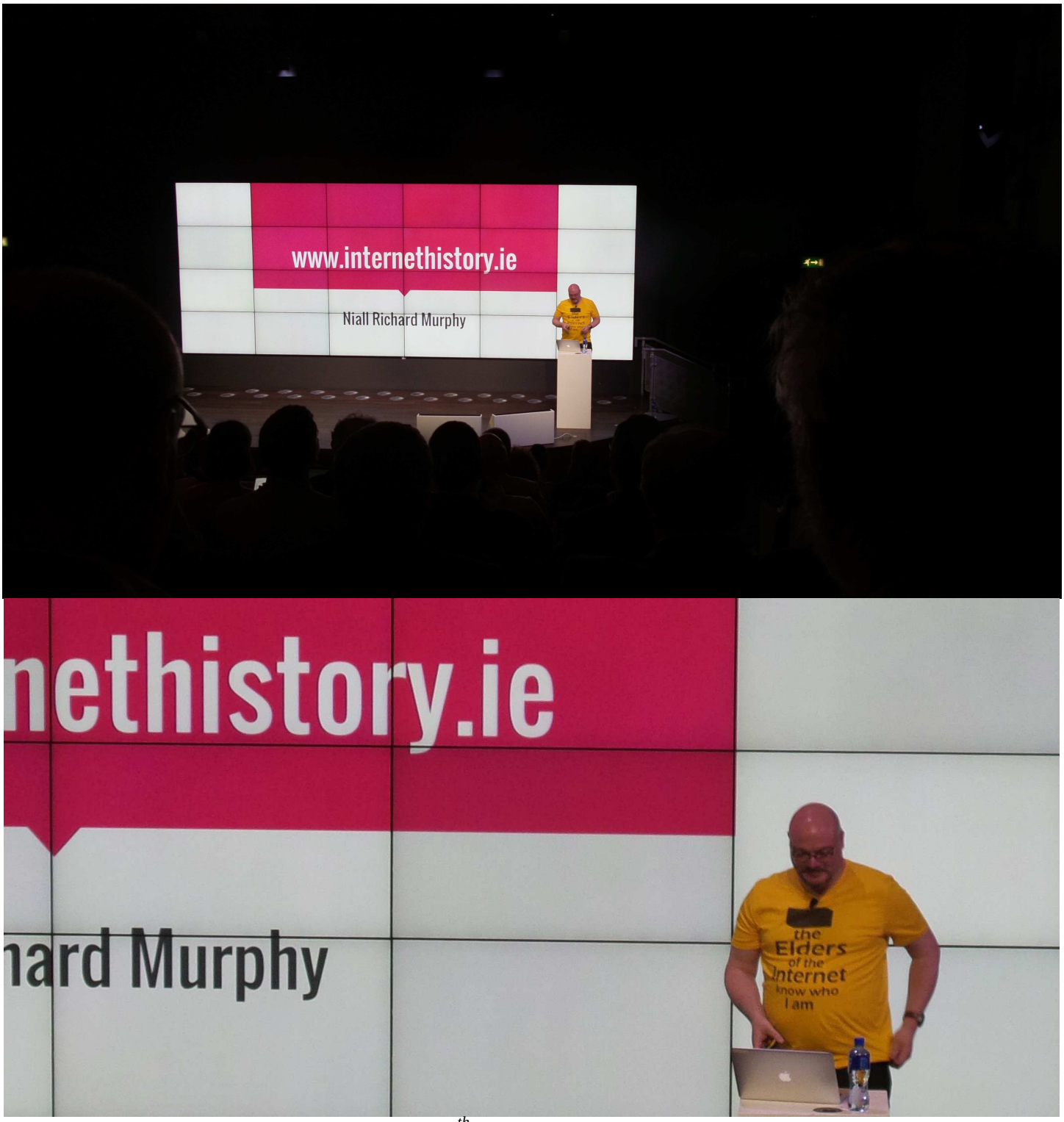

Figure 24: Irish Internet 25th Anniversary Event, Niall Richard Murphy
Niall (of Google) was involved in early ISPs, and hosted the event