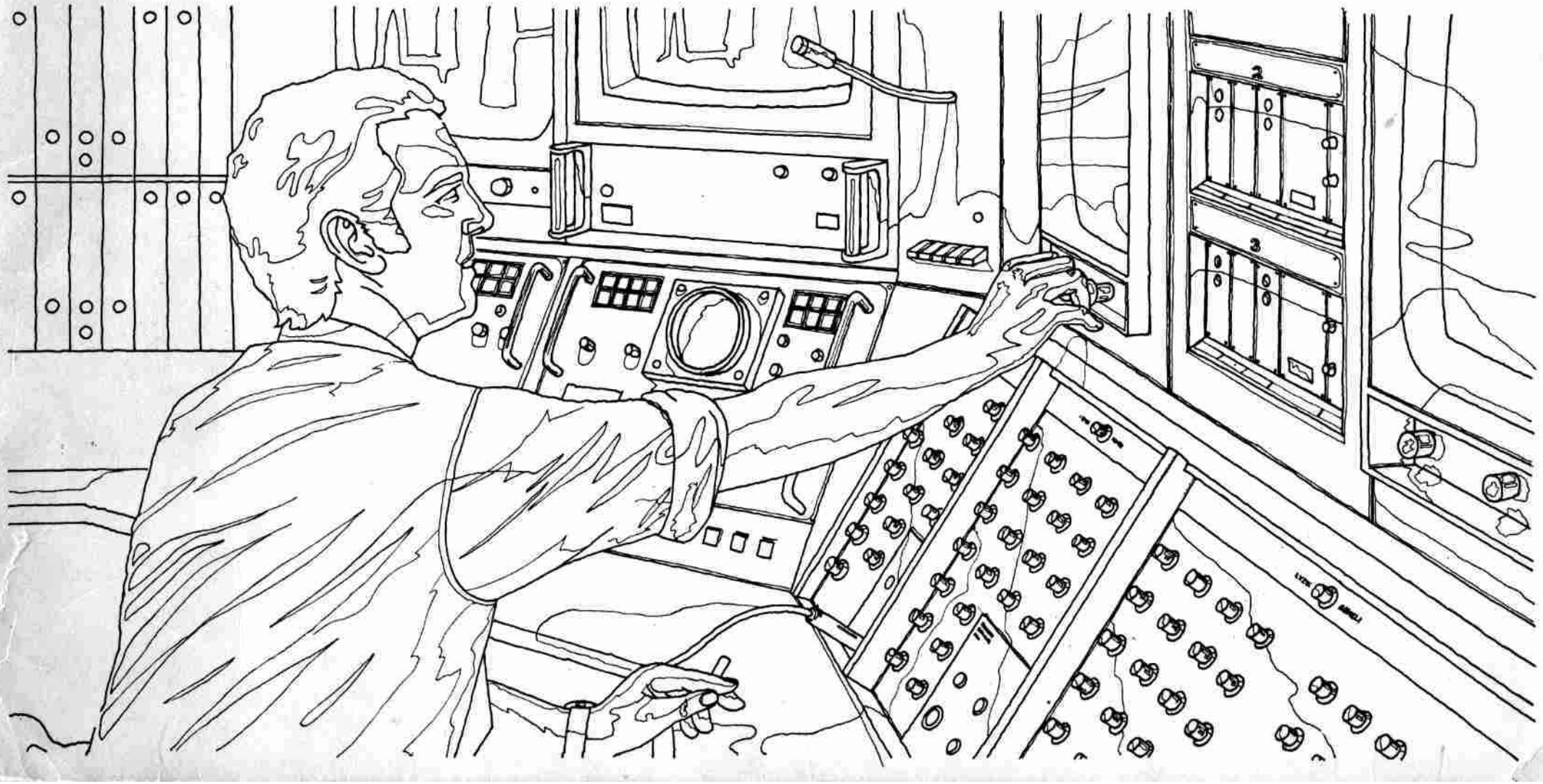
ITA

Independent Television Engineering for Colour



Independent Television Engineering for Colour

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Contents

3 Foreword

The announcement by the Postmaster-General, early in 1967, that Independent Television would be authorized to start duplicated, 625-line, UHF colour services, within three years, presented a unique challenge to what, by broadcasting standards, were still relatively young organizations. The federated regional structure of Independent Television, with its many (and often competing) programme companies linked together through the controlling body of the ITA, which owns and operates all of the transmitters, had emerged during the 12 years of building up the regional services of 405-line monochrome television into a system very different from that of any other major broadcaster.

Could this regional system cope with the challenge of colour based on a network of co-sited ITA/BBC UHF transmitters? How would it be possible to retain the necessary control over our own network of transmitting stations? How, with the much more complex network switching involved in a regional system, and the constant switching between studios many miles apart, could we achieve a colour performance which would truly stand comparison with that of any monolithic broadcasting organization anywhere in the world? Could our system, with its mixture of large and small regional companies, devise a viable duplicated colour system without any additional revenue from a new programme channel? Would it be possible to build the system at a rate which would allow colour to be networked right from the start and so help to share costs? Could we provide all the new transmitting stations, ultimately expected to be more than 500, without a massive and uneconomic build-up of operational staff?

The period from 1967 to the launch of colour from four main stations on 15 November 1969, and the subsequent continuation of the build-up towards national coverage, not only provided the engineers of Independent Television with an exceptionally challenging task, but called also for technical decisions to be taken at an early stage which would inevitably have far-reaching consequences.

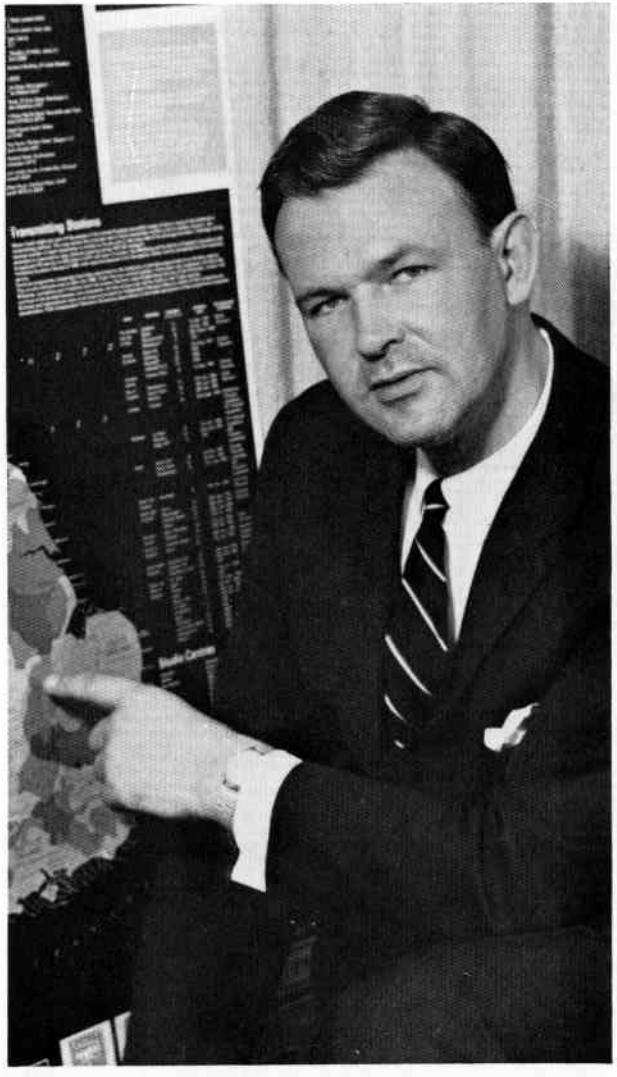
We acknowledge that success has been achieved only by the closest co-operation of all concerned: the new Ministry of Posts and Telecommunications; the Post Office; the engineers of both ITA and the programme companies; and not least those of the BBC with whom we now share sites without in any way affecting the continuation of keen rivalry on the programme side and the operational independence of the two networks.

This booklet–produced with the assistance of the Chief Engineers of the programme companies and their staffs–brings together a few of the technical aspects of launching Independent Television into colour, and some account of present work in engineering development: it is representative rather than comprehensive. With so much still to be done, it is far too early to attempt a definitive account of all the work that has gone into–and continues to go into–Independent Television colour. Perhaps, however, these few brief fragments of the engineering of the new colour operations will be of interest to others professionally concerned with broadcasting.

At least, that is our hope.

Howard Steele

Director of Engineering,
Independent Television Authority
September, 1970



4 Independent Television and Colour

The combined *production* output of the 15 Independent Television companies is roughly equal to the combined production output of the other two British services: this is because Independent Television is a federated regional system, with the programme companies independent of each other. While some programmes are networked, there is substantial regional variety, not only in programme content, but also in the times at which programmes are transmitted.

To meet this requirement, Independent Television is the most extensively equipped colour broadcasting operation in Europe: no less than 187 colour cameras, 76 colour telecines and 60 colour-capable videotape machines are either working, or currently being installed, in Independent Television.

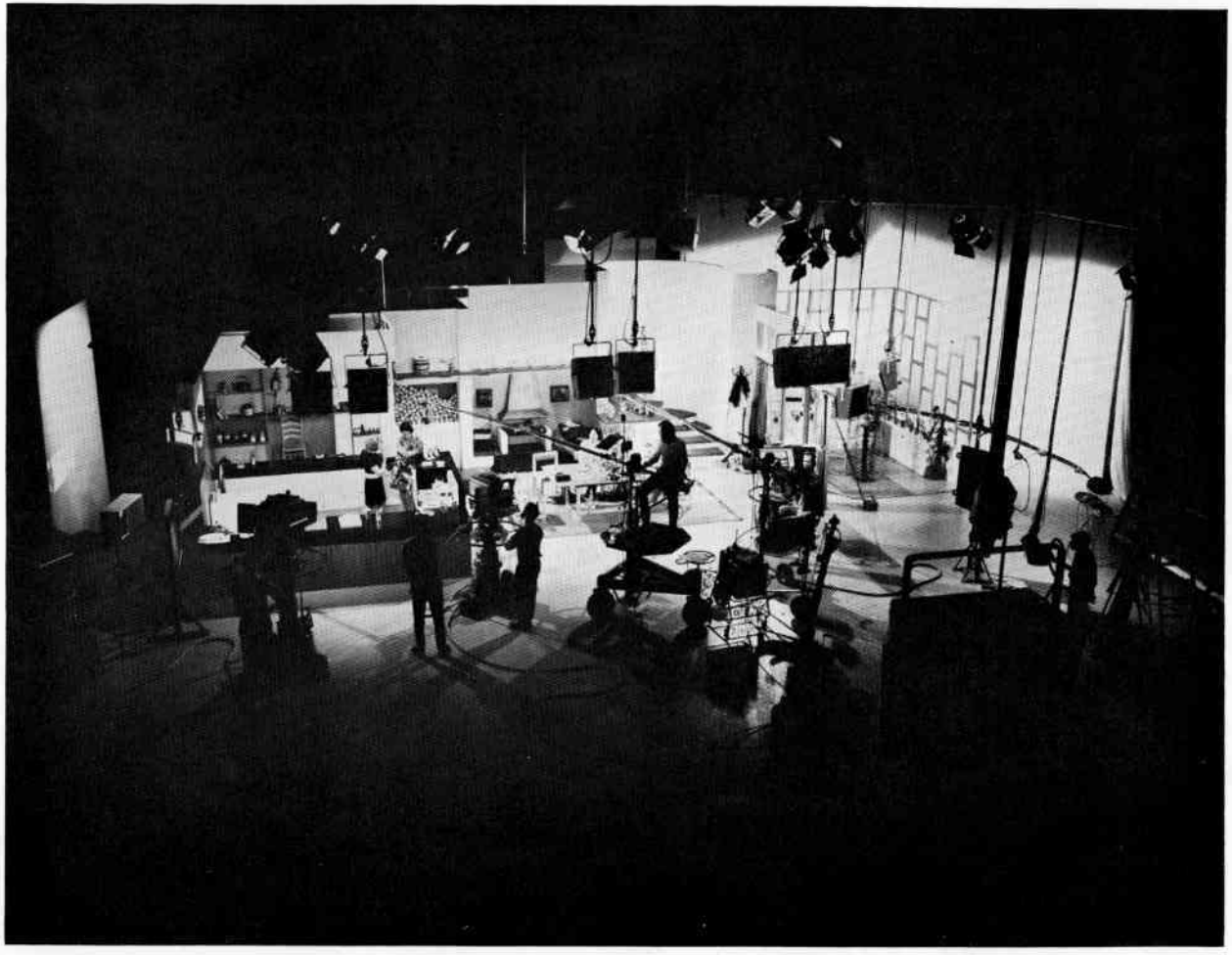
Already, in some regions, Independent Television transmits well over 50 hours of colour each week–including virtually all peak-hour programmes. This was achieved from the start of colour transmissions in November 1969–believed to be the fastest initial colour build-up ever achieved by any broadcasting organization, anywhere in the world.

From the initial launch of Independent Television colour on four high-power UHF transmitters, the network by August 1970 has already grown to 12 high-power stations covering two-thirds of the population of the United Kingdom. During 1969 alone, the Authority installed more transmitter power than in the whole of the preceding 14 years.

All the ITA UHF transmitters are designed for automatic, remote-control operation from 14 new regional colour control centres. The London transmitter at Crystal Palace, with a radio-frequency power of 80 kW and an effective radiated power of one million watts, is the most powerful unattended UHF television transmitter in Europe.

Massive re-equipment by the programme companies and the building of many new studio centres and the extensive colour-conversion of others means that Independent Television colour programmes are being produced in new colour studios or from new colour outside broadcast vehicles, which are among the most modern and best equipped in the world.

An Independent Television programme in production at one of the new colour studio complexes



5 The Independent Television System

The Independent Television Authority was created in 1954 to provide public television services of information, education and entertainment. The system operates as a federated regional system with the programmes produced by 15 companies in 14 regional areas. National news bulletins for all areas are provided by Independent Television News, a non-profit-making company jointly owned by the programme companies.

The ITA builds, owns and operates the transmitting stations; selects and appoints the programme companies; controls the programmes; and controls the advertising.

The programme companies obtain their revenue from the sale of advertising time and pay a rental to the ITA and a levy, based on advertisement revenue, to the Exchequer.

In any one service area, viewers of Independent Television can see about 65 to 70 hours of programmes each week. The 15 programme companies each week provide a total of some 140 hours of different programmes produced in their own studios, accounting for over 50 hours of the programmes seen in any one service area. No programmes are sponsored by advertisers. Advertising is limited to six minutes an hour, averaged over the day's programmes, and a maximum of seven minutes in any single 'clock-hour'.

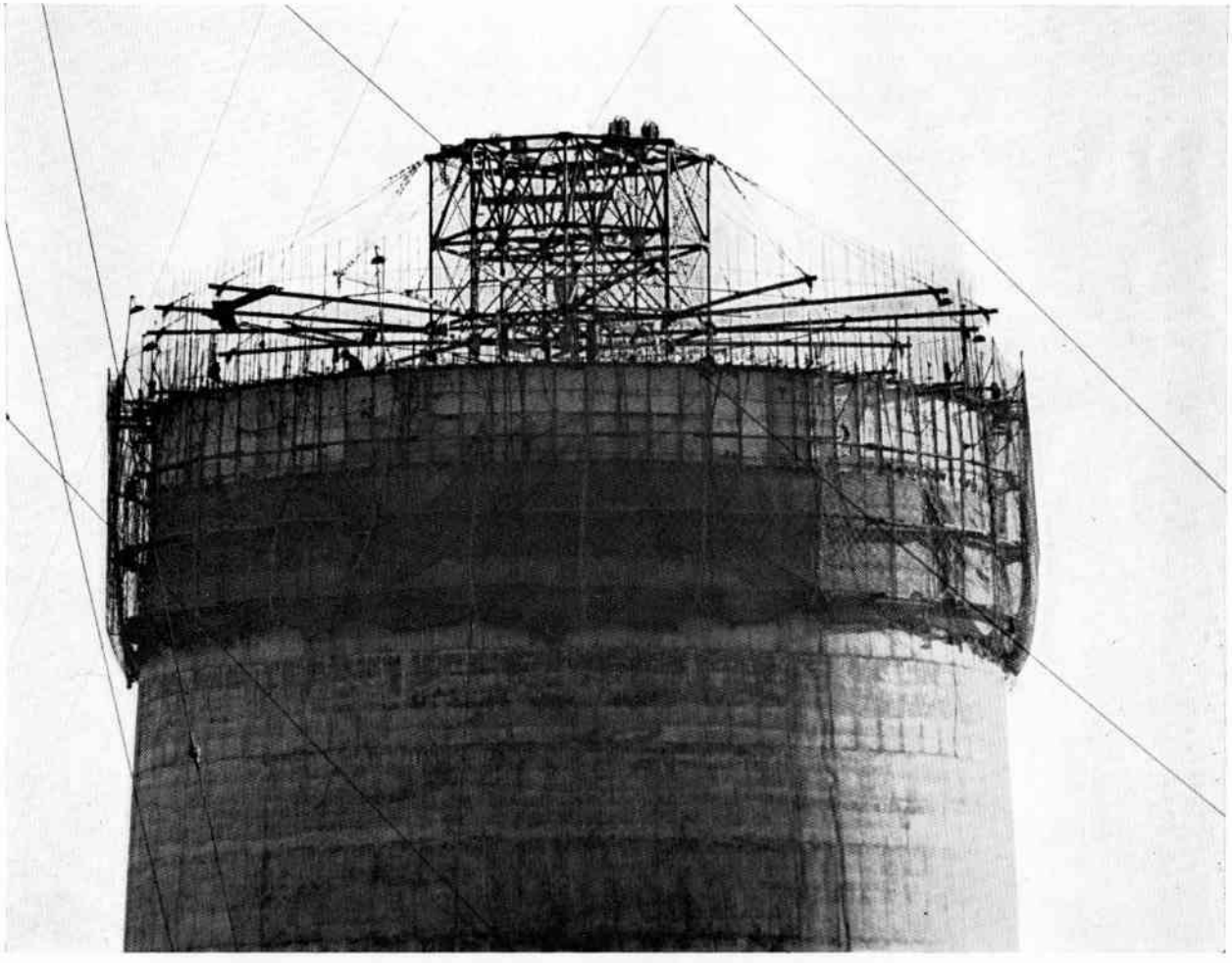
The ITA-controlled Independent Television service began in September 1955 and was the first television service in the United Kingdom to exploit Band III (174–216 MHz). There are now in operation 47 ITA Band III stations providing coverage of 98·7 per cent of the population for 405-line black-and-white transmissions. No further VHF 405-line stations are planned.

The Independent Television 625-line PAL colour services began in November 1969 from UHF transmitters co-sited with those of the BBC 625-line services, sites being either ITA or BBC and shared on a 'landlord-tenant' arrangement; transmitters, however, are controlled independently, all ITA UHF transmitters being designed for automatic or remote control.

The new ITA UHF network is thus based entirely on *unattended* transmitters, even for radiated powers of up to 1000 kW, and r.f. transmitter powers up to 80kW (two 40 kW units), and is the first European network to use integral five-cavity klystron amplifiers.

The ITA is already operating 12 main UHF colour transmitters, reaching two-thirds of the population, and is building many more. Independent Television is producing over 80 per cent of its programmes in colour–considerably more in some regions.

Work in progress on the new concrete tower at Emley Moor–Britain's first concrete television broadcasting aerial support



6 Some Landmarks in Independent Television Engineering

1954

30 July Television Act 1954 received Royal Assent
4 August The Authority set up by the Postmaster-General
1 October Sir Robert Fraser appointed Director General

1955

22 September The ITA's first station–Croydon Channel 9–opened. The single 10 kW transmitter, the first Band III equipment to be constructed in the UK, was a laboratory prototype, the aerial an experimental 8-stack omnidirectional split array on a temporary 200 ft tower. Effective radiated power only 60 kW but provided potential population coverage of 10-million viewers

1956

17 February Lichfield station opened, in the Midlands, using Channel 8 and two 5kW transmitters delivering power each into one half of a split 16-stack aerial
3 May Winter Hill transmitting station in Lancashire opened
13 October ITA and ITCA became members of the European Broadcasting Union
3 November Emley Moor station opened in Yorkshire

1957

31 August The first station in Scotland–Black Hill–opened

1958

14 January The first station in Wales–St Hilary–opened
27 May Mobile laboratory equipped by ITA for experiments in the use of Bands IV and V for television broadcasting

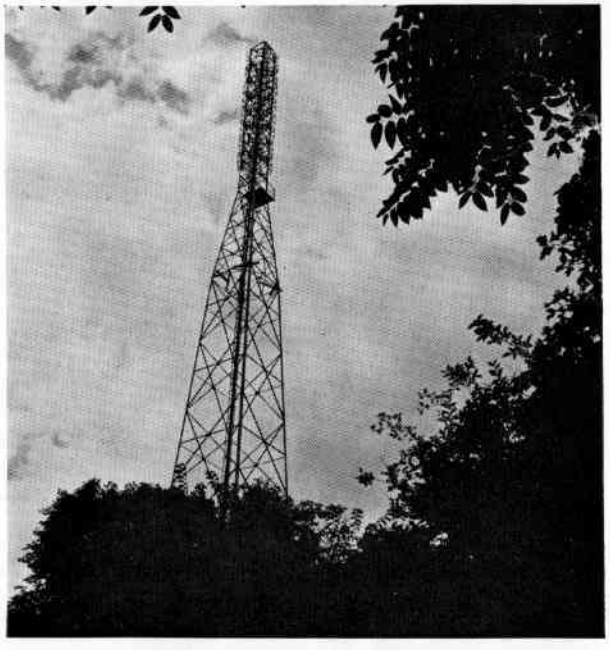
1959

27 October Mendlesham station opened in East Anglia with the then highest mast in Europe (1000 ft)
31 October First ITA station in Northern Ireland opens at Black Mountain

1960

31 January Dover station opened

Sir Robert Fraser, Director General ITA, 1954–1970



Britain's first Independent Television Station

1961

29 April — ITA opens two stations in South-west England: Stockland Hill and Caradon Hill

18 July — New 1000-ft mast brought into service at Lichfield to replace 450-ft tower

19 August — ITA begins move to 70 Brompton Road

1 December — The ITA's first unmanned automatic satellite transmitter opened at Selkirk

1962

11 July — First Independent Television transatlantic transmission via Telstar

5 December — New 500-ft tower brought into use at Croydon. By means of 16-stack aerial, effective radiated power increased to about 350 kW and raising potential audience to about 13-million.

1965

30 January — Independent Television mounts largest outside-broadcast to cover State Funeral of Sir Winston Churchill using 45 live cameras

1967

February — Postmaster-General authorizes ITA to duplicate its existing 405-line service on 625-lines in UHF and to introduce colour into the higher standard

1969

5 September — First experimental transmissions from new Crystal Palace, Channel 23 UHF colour transmitter

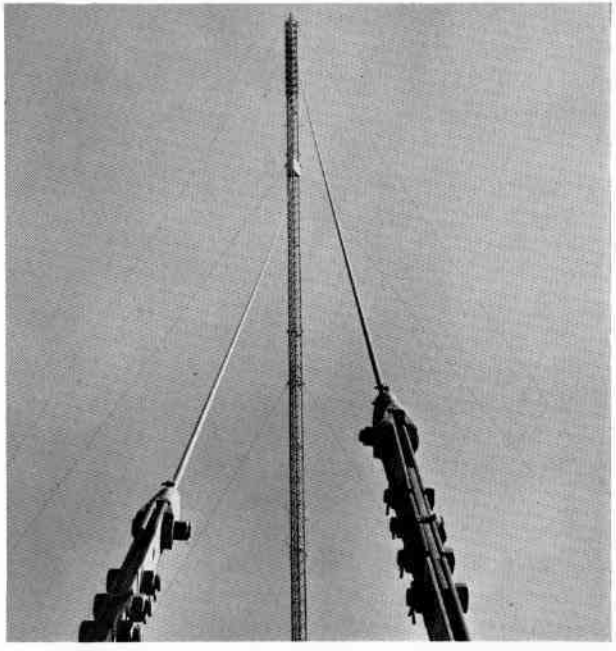
7–8 September — 'S-night' change over to 625-lines throughout Independent Television distribution network

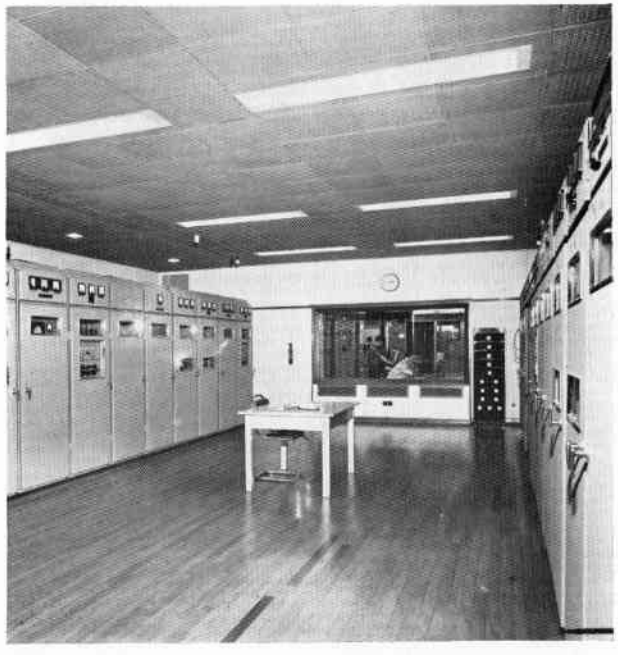
15 November — Start of UHF colour service from Crystal Palace, Sutton Coldfield, Lichfield, Winter Hill and Emley Moor transmitting stations

13 December — Three additional stations–Rowridge, Dover and Black Hill–start full programme service on 625-line colour

1970

New main UHF stations open at Waltham (February), Wenvoe (April), Mendip (May), Oxford (June), Pontop Pike (July), Divis (September)





The 1,000-ft mast at Lichfield which extended ITV's Midlands coverage in 1961

The Winter Hill transmitting Station extended Independent Television to the North of England

8 Planning the Colour Service

The then Postmaster-General announced on 15 February 1967 that Independent Television and BBC1 would be authorized to start colour services within three years, by duplicating the existing 405-line monochrome services, then on Bands I and III, with 625-line PAL colour services in UHF Bands IV and V.

The immediate problems involved in this duplication plan were recruitment and training, the setting of standards and pooling available knowledge. The Authority would then have to plan a new UHF transmitter network comparable to that provided by the 47 VHF transmitting stations which carry Independent Television programmes to more than 98·7 per cent of the population of the United Kingdom.

Because of the propagation characteristics of UHF, some 60 high power and almost 500 lower power relay stations would be needed to provide coverage approaching that of the VHF network. The power of the main stations would need to be of the order of eight times that of the main VHF stations. For example whereas Croydon on Channel 9 VHF can reach over 13-million people with a transmitter output of 10 kW and effective radiated power of about 350 kW, the Crystal Palace station would need 80 kW transmitter r.f. output to provide the 1 MW e.r.p. needed to reach about 10-million people.

It was appreciated, from the outset, that there would be need to build ten, or even twenty times as many stations each year, with each transmitter significantly more powerful, than had been required during the growth of Independent Television 405-line VHF coverage.

Not only had these stations to be built, but the system had to be commercially viable. Independent Television is wholly financed from advertising revenues, receiving no part of the monochrome or colour television licence. The early history of ITV had shown that the programme companies incurred vast losses while waiting for the network to expand to the extent that some production costs could be shared by networking. The new colour network, since it duplicated the existing 405-line programmes, would not result in any significant change in advertising revenues. If 30 or 40 new transmitters were to be opened each year, the costs of operating these stations could not be allowed to rise correspondingly; this was to provide a strong motivation for the decision to make the UHF network comprise entirely unattended transmitters.

But in the first days of planning the new service, the first priority was to expand the nucleus of engineering strength at ITA headquarters. To avoid the temporary recruitment of engineers for the planning and installation work, a new basic pattern of transmitter staffing at the 20 manned VHF stations was evolved, the three three-man shifts being replaced with two-man shifts. Senior transmitter staff were brought to headquarters to help in planning the UHF installations, and others attended crash training courses at Marconi College.

The ITA experimental laboratory was doubled in size and equipped with colour generation, switching, encoding, decoding, monitoring and display equipment to allow staff to gain colour experience; previously all studio equipment within ITV had been confined to programme contractors studios. During 1968, the ITA took delivery of one of the first mobile colour videotape recorder units; also a telecine, slide scanner and control desk. A special colour viewing room was built, and the experience used in the design of the new colour control centres.

Management Decisions

Major engineering decisions were taken at an early stage to allow the vastly expanded UHF/VHF networks to be run by roughly the same number of station engineers as in the past (about 250) while, at the same time, recruiting and welding into an effective team the expanded number of engineers who would be needed for the planning, design, construction and experimental engineering departments.

These decisions included:

1 All the new UHF stations are designed for unattended operation, controlled from a series of 14 identical new regional colour control centres. For example, in the London area, the new ITA UHF transmitter at the BBC Crystal Palace site is entirely controlled from the control centre at the ITA VHF Croydon station, about one mile away. At a later stage in the programme, each colour control centre will be responsible for monitoring and controlling the transmissions from the entire regional group of transmitters, using newly developed telemetry and automatic control techniques.

2 For the first time in Europe, a number of the transmitters use a new type of integral five-cavity klystron valve in the final output stages. The ITA decision to sponsor the development of this klystron in California made possible the use of entirely solid-state driver units, offering the added reliability considered essential for unattended operation. Only $\frac{1}{2}$-watt of drive power, readily available from semiconductors of the 1967 era, is needed to drive these high-gain klystrons to provide an output of 25 or 40 kW.

3 The problems of 405-line duplication were overcome by the use of electronic line-standards converters based on computer techniques, initially developed by the BBC and later commercially available. Following tests, it was decided to plan for a simultaneous switch-over ('S-night') of the entire distribution network from 405 to 625-line operation, accepting that some of the regions would still be served only by the 3 MHz Post Office links intended for 405-line operation.

4 Since, under the Television Act, the Authority is responsible for maintenance of high technical standards on its network, although its engineers have direct control only over the transmitting stations, a new technical control section was set up. This is needed to cope with the many complex problems of quality control and the integration of colour pictures from many different studio complexes, arising out of the federated regional struction of Independent Television. In consultation with the programme contractors, high standards of colour performance were established.

5 To facilitate operation and maintenance of the network a high degree of standardization was adopted, with all the high-power transmitters (except the Marconi 40 kW units at Crystal Palace) for the first phase being provided by a single manufacturer (Pye TVT). A similar standardized approach is being made to the provision of the first group of relay transmitters, now being built by Plessey.

In August 1967 the ITA placed with Pye TVT Ltd a contract worth over £2-million–the largest single contract that it had ever placed–for 25 sets of transmitting equipment for the 625-line service. The contract covered 12 pairs of 25 kW transmitters, 10 pairs of 10 kW, and 3 pairs rated at 6¼ kW. A contract was placed with The Marconi Company for a pair of 40 kW transmitters for the Crystal Palace site where a limitation in aerials made it necessary to provide some 80 kW of r.f. power in order to achieve 1000 kW e.r.p. All transmitters were specified for automatic control and unattended operation.

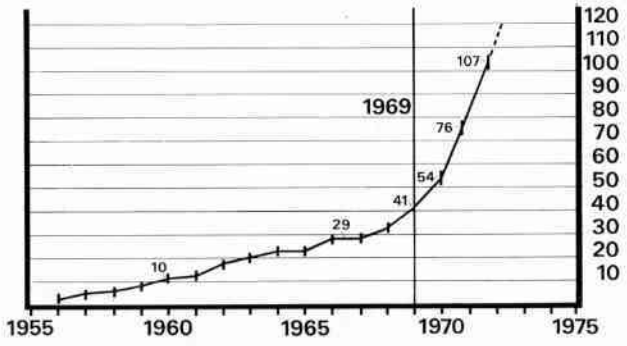
The adoption of the policy of building only unattended UHF transmitting stations with all routine operational tasks concentrated in the 14 manned regional colour control centres has meant that the vastly expanded transmitter networks are designed to be run by roughly the *same number of station engineers* (about 250) as in the past were required for the VHF-only network; this policy was associated with recruiting and welding into effective teams the expanded number of engineers needed for the planning, design, construction and experimental engineering departments of the ITA.

The Planning and Propagation Department of the ITA is responsible for such matters as the overall planning of the transmitting network, in close collaboration with the Ministry of Posts and Telecommunications, the Post Office and the BBC, selecting the sites and arranging for the necessary permission to be obtained from the local authorities. This often involves the carrying out of many surveys and radio propagation calculations in order to ensure that stations will not cause mutual interference, and will provide the required service to the limits of the areas to be covered.

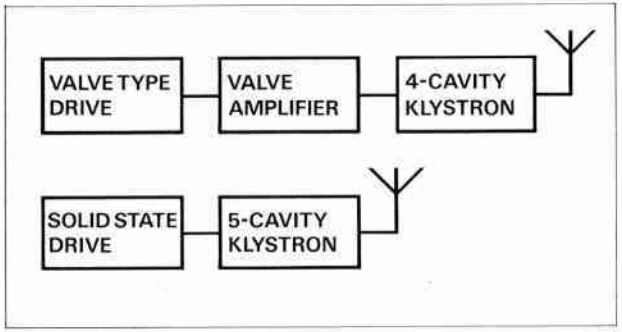
It may be necessary to calculate or determine by pilot experiments whether signals from other transmitters are available in adequate strength for re-broadcasting purposes, or to plan other forms of broadband links to provide transmitters with the vision and sound signals.

Because the UHF co-sited stations have been planned on a national basis right from the start, it seems likely that the best coverage that is possible with UHF should eventually be achieved in the United Kingdom. Nevertheless, it must be recognized that the propagation characteristics of UHF are not ideal, and there will be difficulties in bringing a satisfactory 'off-air' broadcast service to about 5 per cent of the population. There will remain problems in some urban areas due to shadowing and ghosting effects of tall buildings, and in rural areas due to local topography.

In general the service is planned to a 70 dB (decibels above one microvolt per metre) contour for main stations, and 80 dB or more for relay stations. It is anticipated that the final limitation to station coverage will often be the co-channel interference situation arising from the need for many transmitters to share the same channels. The UHF service is planned on the basis that viewers will use effective receiving aerials, and the characteristics of the receiving aerials are specified in the planning standard.



Far left: Cumulative total of VHF and UHF stations–commissioned and projected



Top left: Block diagram of conventional UHF Transmitter

Below left: Block diagram of 5-cavity Klystron UHF Transmitter

10 High Power UHF Transmitters and Aerials

Current practice in Europe and the United States is to use a low level drive unit followed by a modulator and high gain klystron or travelling wave tube; the latter at low power levels only. However, several different philosophies have emerged for the operation of high-power transmitters, the most significant difference being the degree of redundancy. The final choice will tend to be governed by such considerations as the importance or otherwise of securing uninterrupted transmissions, the reliability that can be achieved and long term performance, stability, and amount of time available for maintenance.

While it might appear that a decisive factor would be the absence or presence of operation staff at the transmitter site, it is suggested that present solid-state logic and control circuitry has developed to the point where a reserve or standby condition controlled by logic circuits may be preferable to any form of manual changeover. The control and changeover of power supplies can be effected either remotely or automatically with great reliability; it is only in such areas as r.f. switching that the manual operation of U-links and co-axial switches in high-power transmission lines may still offer some advantages.

There can be little doubt that the best overall service reliability is achieved by the installation of two identical but physically separate transmitters, the output of which is combined in a hybrid network. Failure of any part of either transmitter chain results in a complete shut down of one chain, leaving the other to continue service without interruption; one half of the power is then dissipated in the hybrid balancing load so that an overall reduction of 6 dB occurs in the effective radiated power of the station, but there is no break in transmission. At any time, faulty equipment may be switched into a test load, allowing maintenance to be carried out during programme time. Where a 6 dB reduction is not acceptable, it is possible to bypass the hybrid and so allow

An integral five-cavity Klystron installed in one of the 40 kW transmitters at Crystal Palace

the station to be operated with a 3 dB reduction of power. The disadvantage of full parallel operation is the high capital cost of the plant and station buildings; the advantages include security of service and ease of maintenance. For all present high-power UHF stations, the ITA has adopted the policy of full duplication of equipment.

Because of the agreement between ITA and BBC to share transmitting sites, four-channel UHF aerials are possible for some stations. This has involved the development within industry, and in conjunction with the BBC, of high power aerial combining units to allow the outputs from the considerable number of high-power vision and sound transmitters to be combined and fed together to the aerial arrays. While such combining units are being used most successfully at a number of sites, the first of which was Sutton Coldfield, their development involved extremely difficult technological problems owing to the very high powers involved and the wide bandwidths required. Since initial problems arose at BBC sites, the ITA has acknowledged the tremendous efforts made by BBC engineers, in co-operation with industry, to permit the problems to be overcome without affecting target dates for the new stations.

Considerable efforts have been made by broadcasting engineers in providing smooth coverage patterns for the service areas of the UHF stations. The vertical radiation pattern from linear arrays comprises a narrow main lobe with smaller lobes above and below. The nulls between these lobes produce rings of low field strength, often quite close to the stations. To cater for viewers in these areas, the nulls must be carefully 'filled' by disturbing the phase and amplitude of the currents fed to the tiers of aerial elements. A steady improvement in the results achieved with complex UHF transmitting aerials has been possible in recent years, and this improvement has been achieved at a time beneficial to the new Independent Television UHF service.

Some features of the range of Pye TVT transmitters forming the basis of the first phase of the ITA main station UHF network of unattended transmitting stations include continuous monitoring by solid-state logic, solid-state sound and vision drives and the use of klystron power amplifiers (five-cavity klystrons for 25 kW, four-cavity for 10 and $6\frac{1}{4}$ kW). An interesting method of generating the vision carrier frequency is used. The output of a crystal oscillator of about 8 MHz is applied to a step recovery diode circuit which generates a comb of frequencies, spaced by the crystal frequencies, over the UHF bands. From this the required channel frequency is selected by means of a comb line filter. After amplification the r.f. is modulated in a solid-state reflected circuit. Video pre-correction is carried out prior to modulation and provides adjustment for linearity, differential phase, differential gain, group delay and sync amplitude correction. After modulation the blanking level is held constant by a solid-state feedback circuit. Vestigial sideband filtering is carried out at drive level, the filters being contained in the drive cubicle.

The combining unit is housed in a cubicle located between the sound and vision r.f. power amplifiers.

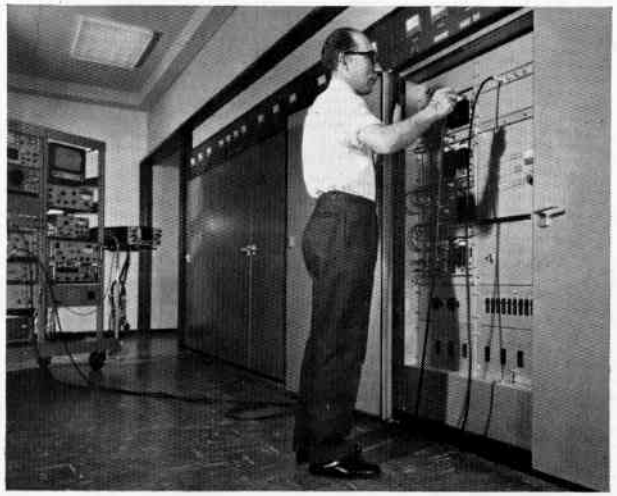
Interconnecting feeders form part of the transmitter package and are located within the cubicle assembly. The unit consists essentially of a coaxial adaption of the Maxwell bridge. Variable impedance matching sections are fitted at all input and output ports.

Switching is carried out by a single start button, the resultant switching sequence being determined by solid state logic circuits. A three shot recovery facility is incorporated so that unnecessary shut down, resulting from a flashover or other transitory interruption, is avoided. Logic circuits also monitor a number of possible fault conditions and apply executive action where necessary. Control may be switched at the transmitter to remote or local positions.

Details of the Marconi 40 kW units used at Crystal Palace are given elsewhere in this publication.

Left: Final installation of a Pye UHF transmitter at the ITA Sutton Coldfield transmitting station

Below: Parallel 40 kW Marconi UHF transmitters installed at the Crystal Palace ITA station–the most powerful unattended UHF transmitting station in Europe



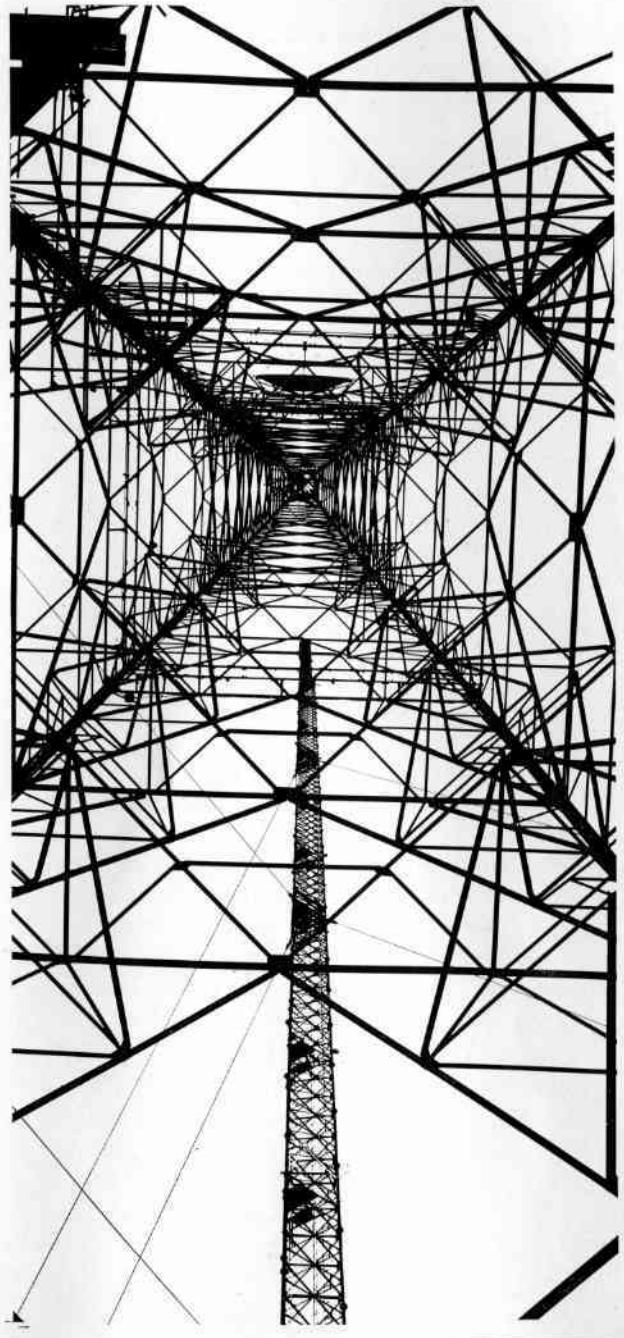
12 UHF Main Transmitting Stations–First Phase

Station	Programme Service Date	ITA Channel	ERP (kW)	Programme Allocation
101 Crystal Palace	15 Nov 69	23	1000	Thames, LWT
102 Sutton Coldfield	15 Nov 69	43	1000	ATV
103 Winter Hill	15 Nov 69	59	500	Granada
104 Emley Moor	15 Nov 69	47	temporary	Yorkshire
105 Black Hill	13 Dec 69	43	500	STV
108 Rowridge	13 Dec 69	27	500	Southern
113 Dover	13 Dec 69	66	100	Southern
111 Waltham	28 Feb 70	61	250	ATV
106 Wenvoe	6 Apr 70	41	500	HTV
110 Mendip	30 May 70	61	500	HTV
117 Oxford	15 Jun 70	60	500	ATV
109 Pontop Pike	17 Jul 70	61	500	Tyne Tees
107 Divis	14 Sep 70	24	280	Ulster
114 Tacolneston	Autumn 70	59	250	Anglia
115 Sudbury	Autumn 70	41	250	Anglia
124 Sandy Heath	Early 71	24	1000	Anglia
116 Bilsdale	Early 71	29	500	Tyne Tees
131 Caradon Hill	Spring 71	25	500	Westward
120 Belmont	Spring 71	25	500	Anglia*
141 Redruth	Spring 71	41	100	Westward
112 Durris	Summer 71	25	500	Grampian
137 Caldbeck	Autumn 71	28	500	Border
147 Craigkelly	Autumn 71	24	100	STV
132 Stockland Hill	Autumn 71	23	250	Westward
126 Hannington	Winter 71	42	250	Southern
139 Heathfield	Winter 71	64	100	Southern
161 Selkirk	Early 72	59	50	Border

*Programme allocation expected to change in 1974

Approximate order of opening of the first series of low power relay stations is:

Reigate, Brierley Hill, Pendle Forest, Sheffield, Wharfedale, Fenton (Stoke-on-Trent), Chesterfield, Tunbridge Wells, Kilvey Hill, Bromsgrove, Guildford, Hemel Hempstead, Keighley, Brighton, Malvern, Fenham, Bath, Lancaster, Rhondda, Darwen, High Wycombe, Lark Stoke, Halifax, Salisbury, Saddleworth, Caerphilly, Skipton, Hertford, Kidderminster, Haslingden, Newton, Pontypridd, and Todmorden.



13 Why ITA Sponsored the Development of the Integral Five-Cavity Klystron

The ITA built its first unattended 405-line VHF relay at Selkirk in 1962, and this established a pattern for many later stations. By the beginning of 1967, when the UHF network was being planned, ITA was operating 10 unattended VHF relays compared with 20 manned stations, and was also building a further ten unattended low-power VHF stations based on a later generation of largely solid-state equipment.

As a result of this pioneering work, serious consideration was given from the outset to the idea of running the new UHF network on a completely unattended basis, even though the problems seemed truly formidable.

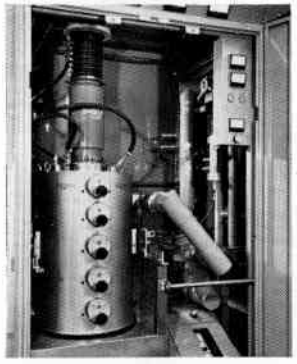
An alternative was the semi-unattended transmitter with only a small nucleus of a staff. It was however appreciated that no matter how small a permanent staff may be, it immediately creates a requirement for offices, rest rooms, canteens, night watchmen, drivers and the like; each station tends to become its own little colony. For this reason, the ITA was determined to avoid, if at all possible, even semi-attended stations.

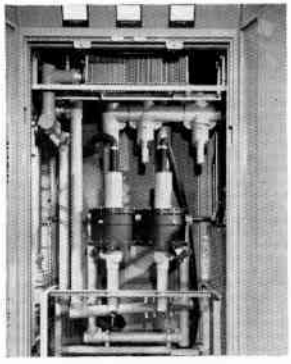
Fully-unattended operation could hardly be contemplated with the generation of UHF transmitters and associated equipment on offer in 1967. These transmitters comprised valve-type drivers feeding a penultimate valve amplifier which provided drive for a four-cavity klystron having external cavities. These external cavity klystrons were already proving reliable, but, when a fault developed, it took some hours to dismantle the cavities, clean them and reassemble them on a new tube. A mobile maintenance team would have to spend many hours on site whenever a klystron failed; a stand-by klystron complete with cavities would have to be kept ready.

Experience in the studios had shown that well-designed solid-state equipment could have a stability and reliability about an order of magnitude greater than equipment based on thermionic devices. The requirement for unattended transmitters thus hinged upon the elimination of the valves used in drive units and the penultimate amplifier. But–at least in the 1967 period–the maximum power output from all solid-state radio-frequency devices was limited, and could not provide the drive needed for the highest-power transmitters using four-cavity klystrons.

At that time, in the United States, some broadcasters were beginning to use an integral four-cavity klystron, which could be reconditioned at the end of its useful life; unfortunately these tubes, though offering significant advantages from a maintenance viewpoint, required even more drive than the equivalent four-cavity klystron with external cavities. There were also indications that the integral cavity klystron might prove to have better stability.

Since British firms were not (at that time) prepared to supply tubes other than external four-cavity designs –for which tooling up had only recently been completed–the decision was made to discuss with firms in the United States the possibility of adding an additional cavity to the integral four-cavity klystron. Some five-cavity klystrons had been designed for specialized pulse applications but were not intended for operation as high power linear amplifiers.





Left: Integral five-cavity Klystron installed in one of the Pye 25 kW transmitters

Right: Internal combining unit built into the Pye UHF transmitters

An extra cavity would result in about 10 dB extra gain. With this additional gain, it would be possible to contemplate the use of solid-state drives, even though these provided only about one or two watts, without any intermediate valve amplifier.

With all-solid-state drive units, and only one klystron in each transmitter, it seemed reasonable to plan the ITA UHF network for unattended operation.

Despite initial development problems (described at IBC68), integral five-cavity klystrons for 25 kW and 40 kW transmitters were successfully developed by Varian and have been used for all ITA transmitters of these power ratings. In conjunction with all solid-state drives, the stability and reliability of this part of the transmitting chain have been well proved. Crystal Palace station was unmanned after a few weeks of test transmissions and before the start of programme service; some other stations were later put into service less than 48 hours from powering the transmitters.

The development of the integral five-cavity klystron has thus proved a significant advance in broadcast engineering, and in conjunction with new shift staffing arrangements at the ITA manned VHF stations and control centres has played a major role in allowing the new UHF network to be run by a station staff no greater than for the VHF network alone. For the lower-power main transmitters, external four-cavity klystrons of established EEV design have been used.

The low-power relay transmitters, being produced for ITA by Plessey, are based entirely on travelling-wave tubes for power amplifiers: no operational experience has yet been gained with this system.

14 Unattended One Megawatt Television Station

The main London ITA UHF transmitting station was brought into service on 15 November 1969. It is co-sited with the BBC transmitters at Crystal Palace in south-east London, but is unattended and normally operates automatically; however it can, when necessary, be controlled from the new regional colour control centre at the ITA Croydon site, about one-mile away.

This station is designed to provide 625-line colour/black-and-white transmissions for over 10-million people in the London area. The station is the most powerful unattended television station in the United Kingdom, and probably in Europe. Aerial gain at the site is limited, and a radio-frequency transmitter power of nearly 80 kW is needed to provide the 1 MW effective radiated power.

Two 40 kW UHF transmitters are operated in parallel, each using one of the recently developed integral five-cavity klystron power amplifiers. Apart from these two amplifiers, no thermionic devices are used in the station.

As a result of GLC stipulations at this site, forming part of an area designated as a public park, all transmitter buildings are below ground level giving rise to unusual cooling and ventilation problems; the station has also had to be designed to keep acoustic noise outside the building barely perceptible. The existing BBC building had been designed to satisfy these requirements, and the ITA building was designed as a matching extension to this.

The bulk of the building, of massive re-inforced concrete construction, is below ground level. Although, for this reason, the size was virtually pre-determined, ample space has been left for a second set of transmitting equipment, should the ITA be asked to provide the fourth UHF service.

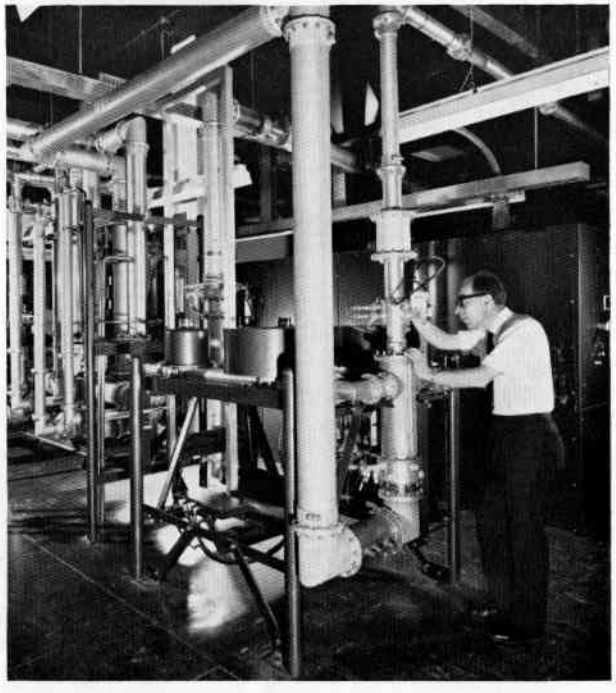
The building is a two-storey structure built into the side of the upper terrace. The underground transmitter hall and several small rooms are at the lower level; all the ventilation and cooling plant (except the water-pumping units) is in the first floor plant area. Cooling air is drawn in the front of the building through a series of silencers, and finally expelled through silencers at the rear. The ceiling of the transmitter hall is higher than the floor of the first floor plant room to allow a straight run for the six-inch diameter main steam tubing which runs from the vapour-cooled klystrons to the heat exchangers.

It is present ITA policy at UHF stations to duplicate the transmitters and always to use two in parallel. At Crystal Palace, two 40 kW (peak sync) vision transmitters provide a total vision output of almost 80 kW; the two associated frequency-modulated sound transmitters are of 8 kW rating, providing the 16 kW required for the British vision-to-sound ratio (UHF) of 5:1. Operating experience with the UHF transmitters throughout the ITA network has shown that the failure rate of individual transmitters has been higher than had been anticipated; however the system has meant that at no time has the service been seriously interrupted due to transmitter faults, though there have been some periods of operation at reduced power.

Duplicated, crystal-controlled drive signals are generated in a separate cabinet which also contains the drive changeover logic and electronic phase control system. There are no electromagnetic relays or other moving parts in the signal path. The f.m. sound signal is also generated in this drive cabinet, the vision-sound carrier spacing being accurately controlled by reference to a high-stability crystal oscillator.

The extremely high gain of the integral five-cavity klystron power amplifiers in the main transmitter units allows an output of 40 kW to be achieved by each amplifier directly from the solid-state modulator, without need for any intermediate valved amplifier. By operating the vision klystrons at a perveance of less than two, a sync efficiency of 30 per cent can be readily achieved. The transmitters are set up accurately to provide high efficiency.

Each transmitter has an associated vision and sound combining unit, which also contains colour subcarrier image rejection filters, power monitors and phase comparators. A diplexer and switching frame allows both outputs to be combined and subsequently split again to feed the two halves of the aerial, mounted on the BBC 700-ft tower. Combinations of U-links allow either or both transmitters to be fed to the aerial or to test load.



High power aerial combining units installed in the ITA transmitter hall at Crystal Palace

Three sump tanks and pumping units–one for each transmitter and one for test purposes–diplexer and splitter loads are accommodated in a shallow pit running the entire length of the transmitter hall. All cooling water drains back to these tanks on shut-down.

Alternative 11 kV power feeders are provided to the station, automatically selected by means of high voltage switchgear housed in a sub-station let into the building. The medium voltage switchroom contains oil-filled moving-coil regulators for each transmitter, with CO_2 fire protection equipment provided.

Steam from the transmitters is condensed by air-blast heat exchangers in the plant room, the condensate returning to the water pumping units under gravity. Each heat exchanger includes two additional blocks: one for cooling de-mineralized water circulated through the klystrons and solenoids; the other for cooling the test-load circuit. Controlled quantities of impurity are added to the test load for use in the 'lossy' transmission-line load.

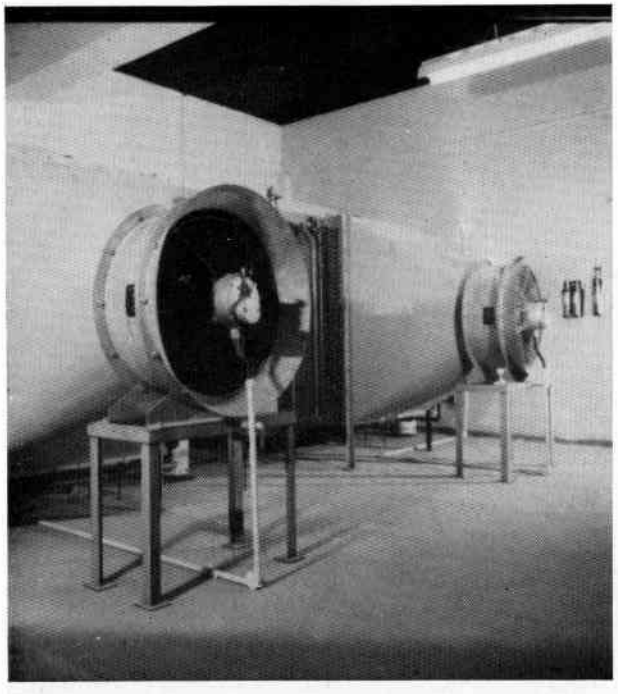
Modulating louvres control the degree of re-circulation through the heat exchangers in such a manner that, whatever the prevailing weather conditions, the heat-exchanger air-intake temperature cannot fall below freezing point. Hot air from the transmitter hall and pump pit is exhausted into the heat exchanger intake area to accelerate stabilization of temperature. The inlet water to the klystrons is stabilized at 60°C, using a mixing valve; this contributes to reaching stable conditions quickly.

The building is ventilated by means of air drawn in from outside the building through a roll filter and then distributed. The temperature in the transmitter hall is sensed by a thermostat acting in conjunction with a further set of modulating louvres to admit hot air from the heat-exchanger area. The transmitter hall is thus maintained at constant temperature.

Automatic functions include switching off faulty equipment by means of the transmitter control circuits, or by changing over to standby equipment. A diplexer balancing-load excess-power-trip turns off one transmitter in the event of a failure of the phasing system.

The programme input equipment provides parallel feeds to the transmitters from either of two incoming lines; if one line fails the other is automatically selected. The low power stages of the transmitter run continuously; incoming synchronizing pulses are detected and turn on the klystron amplifiers.

Remote control indications and alarms are provided in the colour control centre at the ITA Croydon VHF station using a private line. Signals between Croydon and Crystal Palace are exchanged continuously in digital pulse trains, with a number of alarm and indication points being scanned continuously so that information held in a bistable store is constantly updated. This stored information is displayed on the control desk, showing the state of the transmitter control circuits, and of the drives and programme-input equipment. A number of non-executive alarms are also monitored. In the event of an alarm condition, audible and visible indications are provided in the control room. Any power supply failure, in either the remote control or the interface unit, results in the transmitters being held 'on' in order that programme service should not be jeopardized.



Massive heat exchangers are required in the UHF transmitting stations to remove waste heat from the Klystron amplifiers

Crystal Palace transmitter hall showing a UHF test trolley in use. Normally the station is unmanned

16 New Regional Colour Control Rooms

To improve and make comprehensive and effective the quality monitoring of all colour and monochrome programme material received from the programme companies, the decision was taken in 1967 to build and equip control rooms at 14 regional centres. In practice, these centres were all at manned VHF transmitters, although this is not inherent in the system. These almost identical control rooms allow more stringent and precise control to be exercised over the technical quality of the transmissions paths. The ITA is responsible for the technical performance of the Independent Television system, including the output from the programme companies' studios, the Post Office network and the ITA's own networks of television transmitting stations.

Excluding the Channel Islands, there are 13 programme originating regions in the UK. In practice, 14 control rooms have been built, the additional centre being established at Dover for the eastern part of the Southern Independent Television region, where it was determined that an additional control centre offered a more economical solution than the provision of additional Post Office circuits which would be required with a single control centre on the Isle of Wight.

The functions of the new control rooms are:

1 To permit the subjective and the objective assessment of transmission quality both of signals received at the Centre over the Post Office circuits and of the signal after transmission by stations within the region.

2 To monitor the operational conditions and performance of the transmitter network and to exercise control of transmitter switching in the absence of automatic change-over equipment.

Existing control centres at manned VHF stations were neither large enough, nor could they be readily

Right: The ITA colour control and monitoring centre at Chillerton Down, Isle of Wight

Below: Main control suite in the new London colour control and monitoring centre at Croydon

modified to achieve the required environmental conditions. It was considered essential that the viewing conditions in the new colour control centres should be compatible with ideal viewing conditions in the studios and in the homes of viewers. It was also highly desirable that the environmental conditions should be as pleasant and as comfortable as possible for the operations staffs who spend many hours in these centres. A preliminary wooden mock-up of the main control suite was carefully adjusted until the ergonomics seemed right, and looked right. The control rooms were in practice designed as far as possible around the men and their equipment.

The basic dimensions of the control rooms were determined by the necessity to provide adequate space for the control position together with the display and monitoring equipment, and recognizing that operation staff work in these areas for fairly lengthy periods of time.

The initial plan was of the order of 20 ft square with a ceiling height approaching 10 ft; however ceiling height was later reduced since it was found that part of the roof space was required for air conditioning plant and acoustic treatment. The final height is about 8 ft.

Lighting levels were of two types: the operational lighting level and the less-critical maintenance lighting level. Since it was considered that the level of operational lighting should be carefully controlled, all natural light is excluded to permit all control rooms, including those of the programme contractors, to have similar environmental conditions.

Throughout the Independent Television network it has been agreed that ambient lighting conditions within control rooms should be normalized to Illuminant D, and the level of light falling on monitor screens be maintained between 0·1 and 0·2 ft candles. Light is reflected from behind the monitor screens. This use of scattered light dictated that the general decor of the finish should be maintained in neutral colours: walls are covered with grey fabric, with a dark carpet. The ceiling is of egg-crate-type construction with matt-white finish.

Two colour monitors and four monochrome monitors are generally fitted; all monitor screens are of the same dimensions and the brightness levels of colour and monochrome monitors are normalized. The separation between monitor screens and the operating position is approximately six times the picture height. The air conditioning overcomes the heat dissipation of equipment in the control room, about 3 kW.

Acoustic treatment and the use of BBC LS5/5 speakers allows subjective sound quality assessment to be made. The acoustic design was based on a reverberation time of 0·37 seconds, with as many resonances and nulls eliminated as possible. The underside of the ceiling is covered with Stillite which is an absorbent material; suspended about 18 inches in front of this absorbent material are reflecting baffle boards covering about two-thirds of the total ceiling area, with evenly distributed gaps.

Two of the walls are acoustically treated with a mixture of absorbent and reflecting materials; the wall immediately behind the loudspeaker is an uninterrupted reflected surface.

Apart from providing correct environmental conditions for subjective monitoring, measuring and monitoring equipment is fitted to allow objective measurements to be made. Interval test signals allow objective assessment of the vision signal during transmissions, including measurement of amplitudes, time durations, pulse shapes and the derived parameters such as differential phase and differential gain. The control desk is equipped with a precision waveform monitor to carry out amplitude and time duration measurements, including evaluation of sine-squared pulses. To measure differential gain and differential phase, and to check sub-carrier phase, a Vectorscope is provided.

For subjective assessments, colour and monochrome picture monitors are installed, with facilities allowing monitors to be switched to either simple PAL or delay-line PAL. A BBC-designed equipment provides an alarm indication to the control desk operation, should the limits of the sub-carrier frequency be exceeded.

The control operator is also responsible for the associated main and relay stations; control room monitoring of outstations is possible by means of telemetry and supervisory systems using Post Office lines. Where 'off-air' monitoring of outstations is not possible, it is planned to use slow-scan interval test signal read-out for the assessment of vision transmission quality, the display from the slow-scan system being made available to the control desk operator. The operator also has the function of routeing, selecting and monitoring control room signals; duplicated solid-state equipment is being used for many of these functions.

Facilities are available for feeding test signals, slides, apology captions and the like, into the transmitter network; there is also the ability to switch in fixed corrections and 'clean interval test signals' if required. Each installation is also fitted with two electronic standards converters, one operational, and the other for the stand-by chain.

Current projects include the automation of the trade sequence, which comprises periods of music, tone and silence. Later it is also hoped to automate the logging of programme content, and a keyboard has been built into the control desk for this purpose.

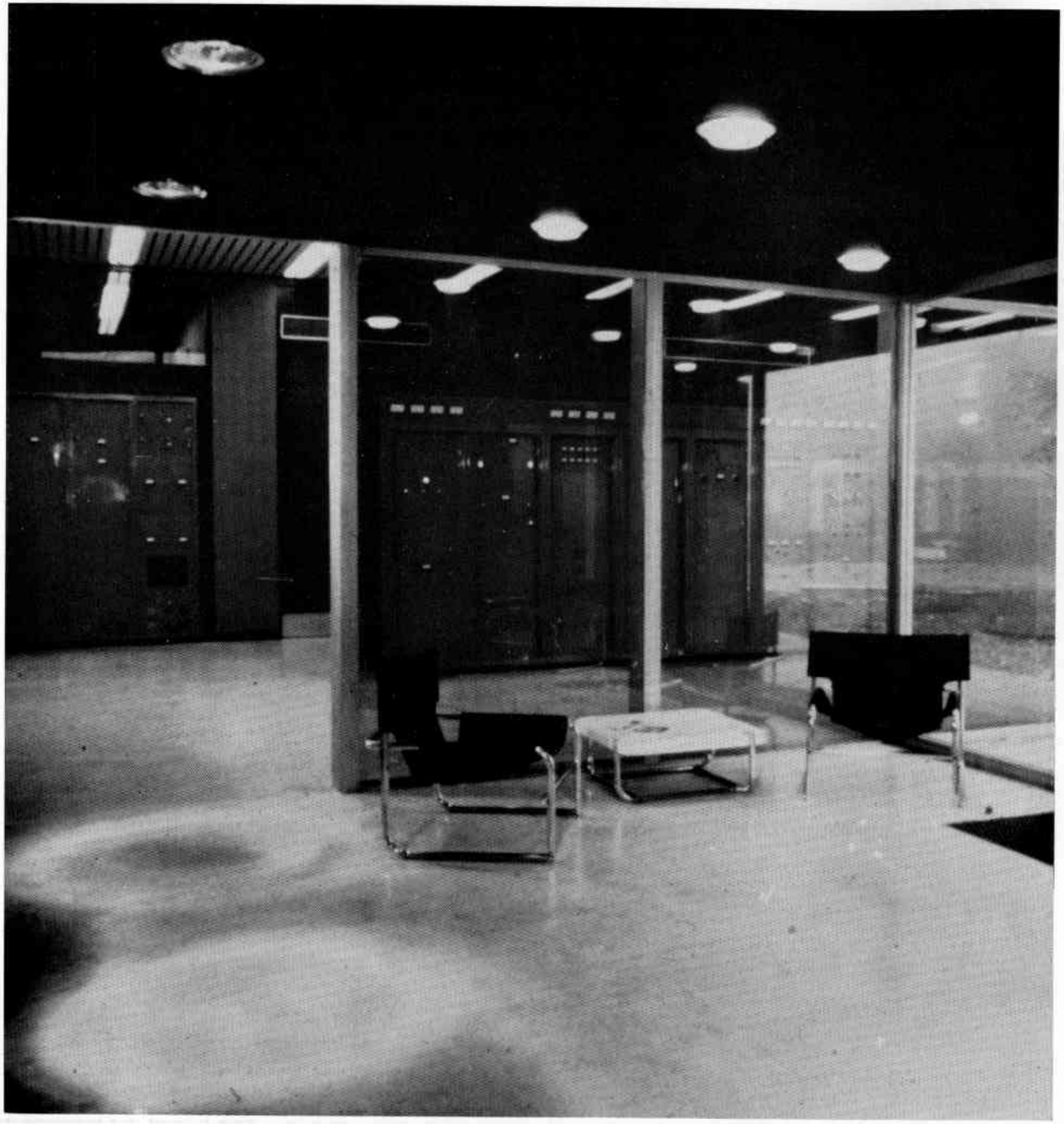
18 New VHF Transmitters at Croydon

Despite the pre-occupation with the 625-line UHF television network, the ITA, during 1969, replaced its sound and vision transmitters at Croydon, and so brought to an end transmissions from the equipments on which Independent Television began its service in September 1955.

The Croydon station, operating on Channel 9, Band III, reaches almost 13·5-million viewers in more than 4-million homes.

The new transmitter units comprise three 5 kW Pye vision transmitters together with associated sound transmitters, combining units and aerial switching units. At any given time, two complete sound and vision transmitters are operational, with one as spare. Power of the Croydon station remains unchanged at a maximum effective radiated power of approximately 350 kW from the directional aerials carried on a 500-ft tower built over a former tennis court.

The VHF transmitters are installed in a new building at the ITA Croydon site which also houses the colour control room for the 625-line UHF service radiated on Channel 23 from the BBC Crystal Palace site.



The reception area of the new ITA building at Croydon

19 Quality Control

Under the Television Act, the ITA is responsible for maintenance of high technical standards on its network, although ITA staff have direct control only over one part of the transmission chain–the transmitting stations.

To cope with the many questions of quality control and the integration of colour pictures from many different studio complexes, a new technical quality control section was set up and now forms part of an expanded Network Operations department. In consultation with the programme contractors a detailed Code of Practice has been established together with an effective control system based on the assessment and logging by the station engineers of the technical quality rating of every programme. The Code of Practice has already been widely accepted by the broadcasting industry; this is only one aspect of the role which Independent Television, as a major customer in the highly specialized field of capital broadcasting equipment, plays in questions bearing on the future technical progress of broadcasting.

The Code of Practice lays down tolerance limits and operational standards which must be observed by every programme company. This code provides the studio planner with a specification upon which to base his design. At the same time, since the specified limits should be realized on a day-to-day basis, it provides a set of performance targets for the operational engineers.

The Code of Practice is divided into two parts: Part A is concerned with the performance of the source equipment and the studio complex as a whole; Part B deals with operational practices.

Since it is impracticable to make test measurements through every possible signal path in a complex studio installation, it was decided to define standard paths based on two different modes of operation. Tolerance limits could then be related to these paths without the need to specify in detail the equipment incorporated in each.

The structure of the Independent Television network requires that each studio centre should have two principal functions. First, it must originate programmes from its own studios; secondly it must accept programmes from the network and supply them to the associated regional transmitting stations. These considerations led to the definition of two standard signal paths–the 'worst path' and the 'direct path'.

The 'worst path' must take into account not only the actual routeing of the signal during transmission but must also allow for the fact that a significant proportion of programmes originate from video tape recordings and, additionally, that most of these contain previously recorded inserts.

For purposes of measurement the direct path is assumed to include only the circuit from the Post Office Terminal equipment through the presentation, switching and processing equipment, back to the Post Office terminal equipment. The worst path is assumed to comprise: the source studio mixer; a looped VTR path; a second studio mixer (to simulate VTR insert conditions); a second looped VTR path; the presentation and master control switcher. All interconnections for these measurements are carried out using normal assignment routes. Degradations due to signal sources (cameras, telecines, etc) or video tape machines are not included, since tolerances for these are specified under Section 3 of the Code of Practice. For the guidance of manufacturers of equipment, copies of the latest issue of the Code of Practice are available from ITA.

A Working Party exists to maintain a continuous review of the Code and many aspects of studio centre performance are almost always under discussion. For example, current questions include: standardization of viewing conditions and monitors; type and location of colour signal processing equipment; synchronization between studio centres; use of electronic masking and film correction.

It is accepted that if the Code of Practice is to succeed in its primary objective of maintaining the highest possible technical quality, it must be modified from time to time. It is expected that new editions of the Code will be issued about once per year as the result of new developments in testing technique and studio equipment.

Among the many techniques used by the ITA engineers in making measurements in the studio centres of the programme companies is a new noise meter which has recently been introduced by the Experimental and Development Department of the Authority. This meter incorporates many special features to assist studio measurement, including the ability to measure noise in the presence of line and field syncs, and to measure the noise output from any single head of a quadruplex VTR machine. The new noise meter also provides a convenient means of measuring the total Moiré effect; using the meter to inspect the output of a decoder from one head only, it is possible to assess the combined Moiré effect by direct measurement. Separate Moiré tests are carried out for each primary and each complimentary colour, using full amplitude, 100 per cent saturated signals. With the aid of the ITA noise meter, the noise level from each of the four heads is measured at the red channel output of a decoder, and the reading converted to a peak-to-peak figure.

The New 625-line Colour Television Transmission Network

The ITA rents from the Post Office, on an annual basis, some 39 trunk inter-city circuits, totalling 2993 route miles, plus all the 'local ends' between the PO network switching centres and the various studio centres and transmitters. In London alone, there are almost 100 local ends converging on the PO switching centre at the base of the Post Office Tower.

Early in 1967, only a few parts of this complex network had a bandwidth nominally capable of carrying 625-line signals, and even some of these would not give adequate performance for PAL colour operation. The main backbone of the network, having been the first part to go into operation, had been designed for 405-line, monochrome operation only. Within seven days of the official announcement that Independent Television would be authorized to begin a colour service, the Post Office were asked to upgrade or replace the main links between London, Birmingham, Manchester and Leeds.

The scale of the changes needed for a new country-wide colour service may be gauged from the following statistics: the current network includes 5500 channel miles of vision links (4000 miles point-to-point links and 1500 miles spanned by 30 rebroadcast receiver links); this network interconnects 15 programme companies and ITN, 16 network switching centres and approximately 60 VHF and UHF television transmitter sites. This network will need further significant expansion as the UHF transmitter network builds up.

To enable the service to be duplicated in colour it has been necessary to: (a) re-engineer the studios and outside-broadcast equipments to 625-line standards; (b) provide the new UHF transmitters–in the next ten to fifteen years their number may increase to over 500; (c) extensively to re-engineer the vision circuits to meet the stringent 625-line PAL colour performance standards and to augment them to serve the increasing number of UHF transmitters; (d) provide line standards converters at 14 main VHF transmitter sites to obtain a 405-line monochrome signal from a 625-line colour network feed; (e) introduce new 625-line operational and maintenance techniques.

The requirements of 625-line colour vision circuits differ from those for 405-line monochrome operation in that: (a) the waveform performance must be maintained for the wider bandwidth circuit; (b) the non-linearity performance must be critically controlled in order to ensure that cross-modulation between luminance and chrominance channels, which appears principally in the form of differential gain and phase, is kept within close limits; (c) a better signal-to-noise performance is required and this must be achieved within the wider bandwidth; (d) the difference in transmission gain and delay between the luminance and chrominance channels must be maintained within close limits.

The up-grading of the vision circuits involved a number of different types of transmission circuits. It was considered, for example, that carrier transmission on 9·5 mm co-axial pairs, as used on a number of 405-line circuits, would be unsuitable for 625-line operation. Most of the circuits using unbalanced video transmission on 4·4 mm and 9·5 mm co-axial pairs have been found suitable with minor modifications for 625-line monochrome transmissions; it is necessary to re-correct them and fit new amplifiers for satisfactory colour performance, often requiring additional intermediate amplifiers. The performance of frequency-modulated radio-relay links varied widely, with some recently installed links already suitable for 625-line colour but with some earlier links barely adequate for 625-line monochrome.

By 15 November 1969 new temporary radio-relay links had been brought into service by the Post Office between Birmingham and Manchester and the link from Manchester had been provided to colour standards. Vision circuits to Crystal Palace, Lichfield and Winter Hill transmitters had been converted, and temporary circuits between Leeds and Emley Moor were in service. Now, in September 1970, new permanent radio links are in service on the route London–Birmingham–Manchester, and colour capable circuits have been provided to Glasgow, Southampton, Dover, Plymouth, Cardiff, Newcastle and Belfast.

The large switching equipments of the Post Office in London, Birmingham, Manchester and Carlisle had been designed with a view to 625-line colour operation and did not have to be modified; however, many distribution amplifiers in smaller switching equipments at other switching centres and the clean-feed equipment on the network output from the Southampton–London vision circuit have had to be changed.

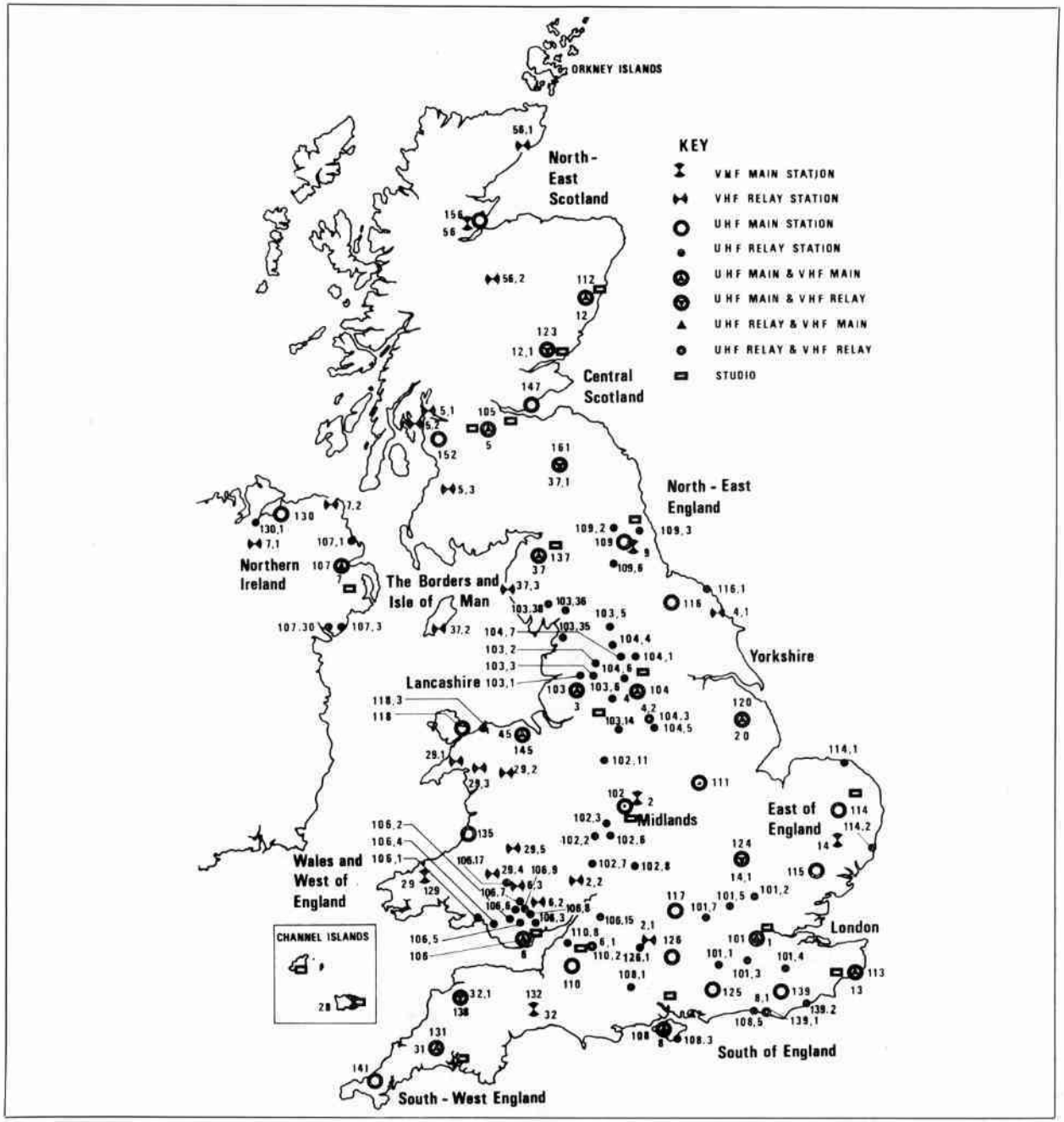
The successful transmission of 625-line monochrome signals over vision circuits initially designed to 405-line standards was achieved after a number of tests and minor modifications.

The network has been equipped with a comprehensive range of test equipment to allow 625-line repetitive line frequency tests on the luminance and chrominance channels. Generators for producing the UK national chrominance insertion test signals are being provided; these signals are inserted on the network feeds from all programme companies and from ITN and at the main UHF transmitters. Source identification signals are connected to vision and programme circuits before transmission.

A critical moment in the preparations for the launching of Independent Television colour was the changeover of the distribution network from 405-line to 625-line operation. This took place during the night of 7–8 September 1969 ('S-night') and entailed transporting the electronic line-store standards con-

verters from the studio centres of the various programme companies to the manned VHF transmitting stations. Before that date, many Independent Television programmes were already being originated on the 625-line standard, but converted at the studios to 405-lines before distribution to the transmitting stations. Since the changeover, all programme companies, except Channel Television which obtains its network programmes by direct reception of VHF broadcast transmissions, have ceased to originate programmes on 405-lines. During 'S-night' 21 of the complex standards converters were transported to the transmitting stations, involving journeys of up to more than 100 miles. The entire operation was carried out successfully and no programme time whatsoever was lost.

Since it seems likely that 405-line VHF transmissions must continue for many years to come, the Experimental and Development Department is currently investigating the design of a digital-form of electronic line standards converter making considerable use of integrated circuit techniques.



ITA Transmitting Stations by the mid-Seventies

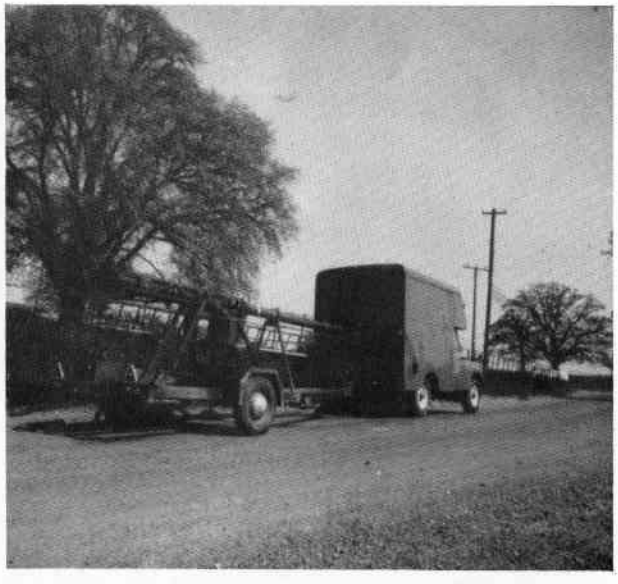
22 Survey Vehicle

In order to obtain information at proposed transmitter sites relating to the operation of rebroadcast (RBR) links, the ITA have brought into operation a mobile survey unit having a trailer-mounted, telescopic mast extending to heights of 30 metres–almost 100 ft.

The mast is mounted on an extended 'A' frame chassis of overall length of 5·75 m with a single pair of central wheels and retractable 'jockey' nose wheel.

The mast consists of nine telescopic sections ranging from 5 cm to 15 cm diameter with a retracted height of 5·5 metres. When retracted, the mast can be cranked and locked in a horizontal position, being pivoted about a point above the basic chassis. A detachable 4-metre ladder can be placed on the chassis and against the bottom mast section to enable the operator to attach aerials on the retracted mast prior to erection.

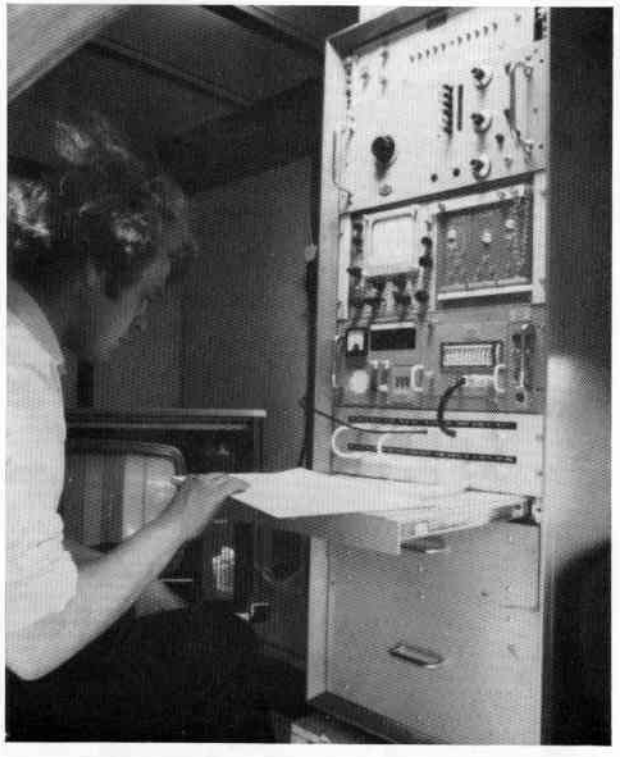
Views of the ITA survey vehicle and the trailer mounted telescopic mast which extends to a height of almost 100 ft



Stabilizing and levelling jacks are placed on four corners of the trailer chassis. The aerial feeder cable is fed through eyelets located on the collar at the top of each section and locking rings can be operated manually on consecutive sections during erection should it be required that the mast remains fully erected over a considerable period. The mast is fully rotatable within its base mounting and a graduated ring has been incorporated with a pointer on the base frame for ease in defining aerial bearing relative to chassis.

The mast is operated by means of a petrol driven compressor unit on the trailer chassis, an air valve enabling the operator to raise or lower the mast as required. A height indicator is positioned so that it can be read by the engineer operating the compressor control valve so that discrete height increments can be obtained.

The mast trailer is towed by the main survey vehicle, a four-wheel drive, three-ton chassis provided by a long wheel base Landrover cab. A drum winch, driven off the vehicle transmission, has been fitted on the front of the vehicle for manoeuvering the mast trailer under particularly arduous site or access conditions. A portable petrol generator provides the primary power source for the operation of the test equipment, including the colour television monitor.



23 Automation of Trade Test Transmissions

It is the practice of the ITA to provide transmissions of test cards, music and audio tones for the benefit of the trade and the receiver installation technicians in periods outside normal programme hours. In the past, these transmissions have been originated at each main VHF transmitting station; however with the building of the UHF network, the operational staffs are being concentrated at the 14 new regional control and monitoring centres. At these centres, the technical quality of all transmissions is monitored and controlled, and all trade test transmissions are originated.

The routine production of a complex sequence of test cards, pictorial slides and various station announcements imposes a burden on the operational staff which it was wished to eliminate or minimize; however central generation of these trade transmissions was not practicable, since the programme distribution network is not normally available during this time. The information, including identification of the stations, is partly of a regional character.

For these reasons a new automatic system has been developed for the regional control rooms to produce a predetermined pattern of sound and vision sources: typically the sequence includes the transmission of Test Card F, a pictorial slide sequence, a synchronized sequence of slides for programme promotion, colour bars, and–on sound–the station identification plus service announcements, a period of continuous music, programme promotion, a period of 400 Hz tone and a period of silence.

Each predetermined sequence repeats at 30-minute intervals, and the order of sources may be varied to suit any desired pattern in which times of the segments are related to one-minute steps.

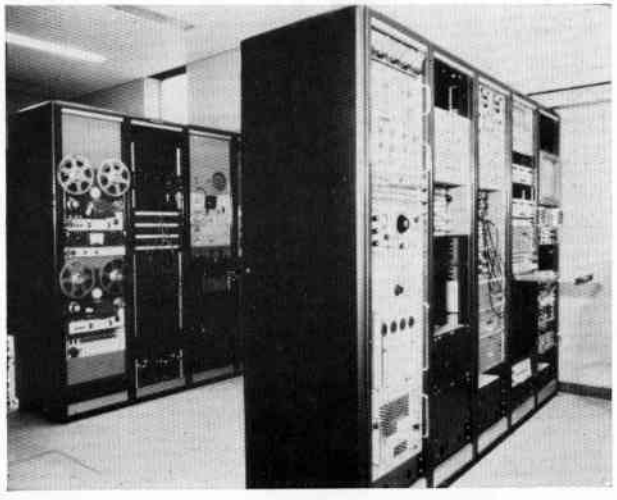
Each control room is provided with a digital clock time display; from the counting chains, five time cues are derived which each repeat at 30-minute intervals. Each of these five time cues may be set to occur at any minute within the 30-minute period by means of a programme plug board. The cues are routed to registers, via vision and sound plug boards, each register bit being associated with a source or condition of a source. Push buttons are provided so that manual initiation of the sequence can be carried out at unprogrammed times. The registers in the control unit act on a five-way solid-state audio switch, the output of which is routed via an automatic sound fader, with the system arranged so that switching occurs only during a fade down. Vision sources are selected in a solid-state video switching system, normally operated manually by push buttons on the control desk; for automatic operation these controls are overridden by the selecting registers in the control unit. Since the action is high-speed it has not been found necessary to employ field interval switching. The main video signal source is a flying spot slide scanner accepting a 30-position magazine of 2 in. by 2 in. slides; random access to all positions is provided. Pictorial information slides are used in addition to the standard test card. The test card has a predetermined position in the slide magazine and the control unit is capable of selecting this position directly, as set up on a thumb wheel switch. The pictorial and announcement slides are normally arranged in two sequences, the first and last slides in each sequence being selected on thumb wheel switches. When the control unit selects slide sequence 1, the first slide is placed in the gate by means of random access logic; subsequent changes, one position at a time, are initiated by the cue track on the cassette machine.

When the second sequence of slides is selected, this is changed by an internal timing device at regular pre-set intervals.

Currently, Test Card F is being transmitted with the first 12 lines of picture information replaced by standard EBU colour bars. This is achieved by gating the slide scanner encoder, and with a second encoder fed from a colour bar generator.

The position of the slide magazine is displayed in digital form on the control desk, and the automatic control unit can be overriden from the desk. Apart from the slide scanner, two other video sources are catered for: the incoming line from the studio centre and a third source at present unused but available for full frame colour bars or other future requirements.

Part of a typical technical area for the origination of trade transmissions from an ITA station. New equipment will allow the automation of trade sequences



24 Technical Facilities

Early in the planning for Independent Television colour, the ITA experimental laboratory in London, which until 1967 had been relatively small, was doubled in size. In order to allow engineering staff to gain colour experience, the laboratory was equipped with colour generation, switching, encoding, decoding, monitoring and display equipment; previously studio equipment within Independent Television had been confined to the studios of the programme companies. Furthermore, during 1968, the ITA took delivery of one of the first mobile colour videotape recorder units to be equipped in the United Kingdom, a colour telecine, slide scanner and control desk. The building of a specially-designed colour viewing room, with the facility to introduce various types of distortion, allowed ITA engineers to investigate equipment performance and the colour parameters to which the new colour service would be required to work. Much of what was learned in the operation of the colour control suite was later incorporated in the design of the 14 new regional colour control centres from which the entire network of unattended UHF transmitters is being monitored.

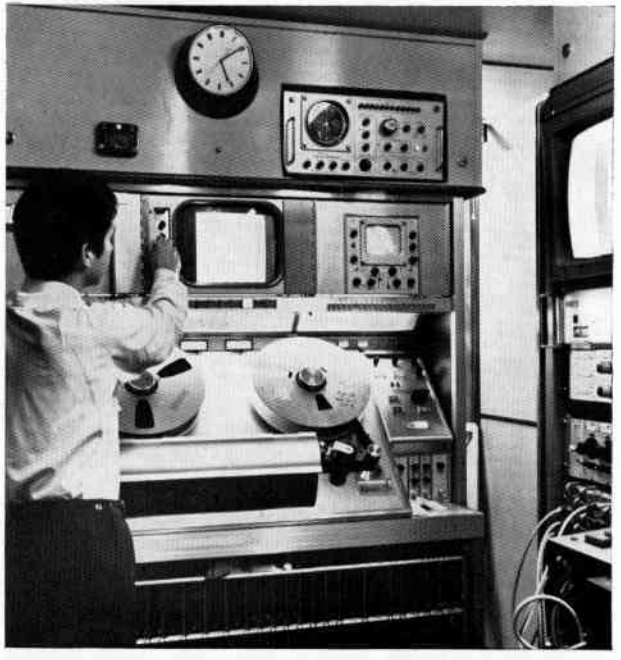
As a service to advertising agencies and others who require the use of modern colour facilities, all the ITA facilities are available for hire. The range of equipment includes:

Central Control Room
Cintel 35 mm flying spot telecine; Cintel 2 in. by 2 in. slide scanner; 10 in. by 12 in. caption camera with colour synthesiser; high-grade EMT turntable; Plessey tape cassette player; sound and vision mixing.
Vision, music and control lines connect with the Post Office Tower, the ITA conference hall and the viewing room.

Mobile Colour VTR
This incorporates an RCA TR70 VTR equipped with full colour ATC and chroma and velocity error correction and capable of working from internal or external pulses. When at base, lines connect the parking bay to the control room and allow replay to the Conference Hall or Colour Viewing room, and recording from the telecine or from any external source. For exhibition use, a simple colour slide scanner, off-air receiver and sound and vision switching can be installed.

Cintel Twin Lens Flying Spot Telecine
The 35 mm telecine is for combined optical sound only. The equipment is set up in accordance with the recommendations of the ITCA and is operated by the Quality Control Section of the ITA. The use of flying spot telecine is particularly appropriate for the assessment of colour commercials since this type of telecine is almost always used for transmission. Although TARIF is not used on commercials transmitted by the Independent Television programme companies, it is available in these facilities to enable a quantitative assessment to be made of colour errors.

Colour Viewing Room
The colour viewing room has been designed by the Ware McGregor Partnership to provide optimum conditions for colour and sound assessment. Luminant 'D' fluorescent tubes provide a colour reference. Two 25-in. Pye professional colour monitors and domestic standard colour receivers are available for colour and compatible monochrome viewing.
A Rank Aldis 16 mm projector is available for optical projection preview and is equipped to handle combined optical and magnetic tracks.



Top: The ITA central control room for its colour facilities, the window provides a view into the special colour viewing room

Below Inside the ITA mobile VTR unit fitted with a TR70 high-band colour tape machine.

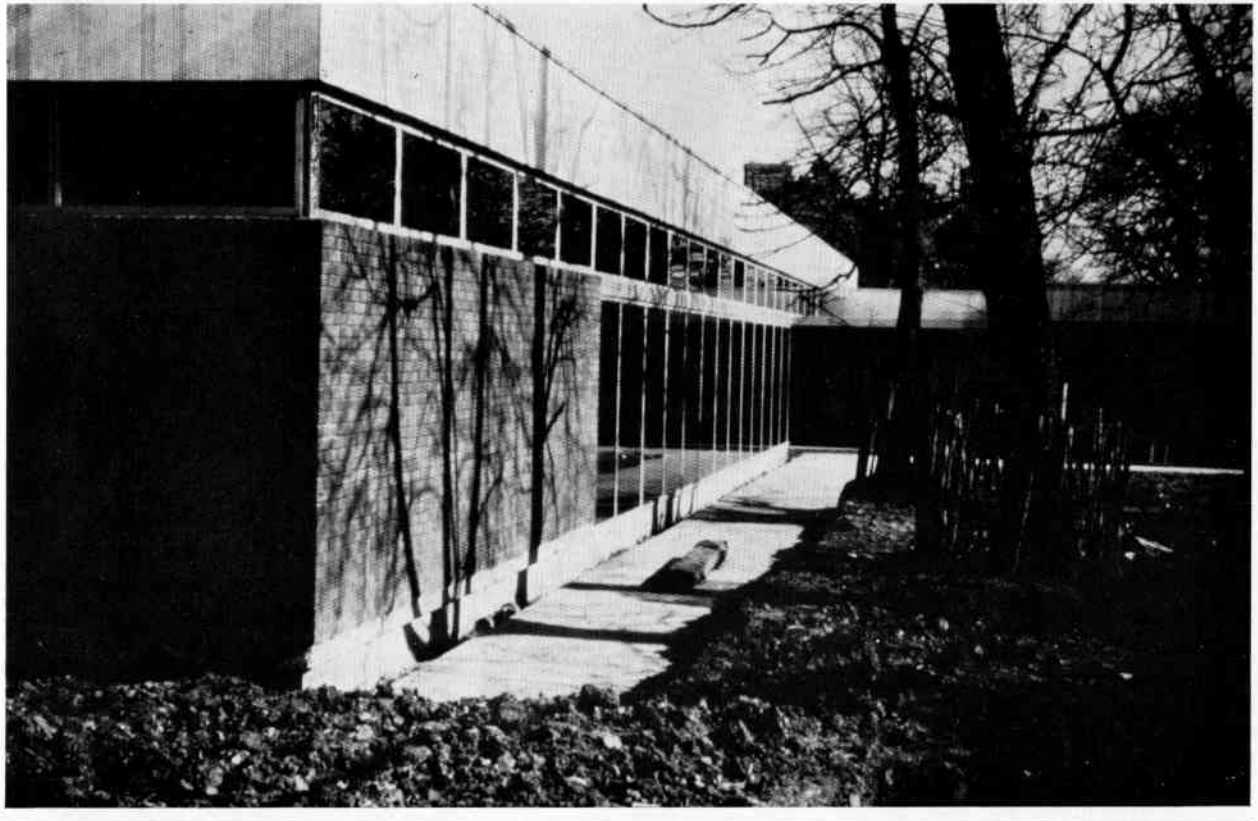
25 Building Designs for Transmitters

The appreciable number of local relay stations which will be required for the new UHF colour services has encouraged the ITA to develop new building designs for these stations. The new building designs have been used initially for the completion of the programme of VHF relays, first at Aviemore and later at Brecon.

The new design pays full regard to the preservation of amenity appearance and the building is designed to be secure in its own right, thus eliminating the need for an unsightly security fence. A small enclosure houses all utility meters so that a mobile maintenance team does not have to be in attendance to allow the electricity meters to be read.

The floor of the building is equivalent to the tailboard height of a lorry to allow future test equipment to be wheeled on a trolley direct from the vehicle onto the floor of the transmitter hall.

With qualified architects and civil engineers on the ITA staff, a number of pre-fabrication techniques are being studied for the future, including the incorporation of the base of the relay aerial support tower (often of the order of 150 ft for relay sites) within the building.



Top left: The ITA transmitter building at Crystal Palace

Top right: One of the new building designs for unattended relay transmitters

Below: The new Croydon building which houses the VHF transmitters and the new London Colour Control and Monitoring centre

26 Emley Moor–from Near-Disaster to Concrete Innovation

The sudden collapse, on 19 March 1969, of the 1265-ft (386-m) tubular steel mast at Emley Moor, Yorkshire–which at the time of its erection in 1966 was the highest structure in Europe–meant that almost six-million viewers were suddenly deprived of Yorkshire Television programmes throughout the region. A disaster of this magnitude could have threatened the planned service dates for the introduction of colour television, not only in the Yorkshire region but also throughout the country.

The energetic steps taken to restore the Independent Television VHF service resulted in programmes again becoming available to roughly 70 per cent of the viewers in a period of only four days, and to virtually all viewers in the astonishing time of under four weeks. Later in the year it was to prove possible to introduce colour in the region on the planned date of 15 November using a low BBC UHF aerial mast and reduced transmitter power.

With the help of British and Swedish industry, the ITA were able to bring from Sweden, erect and bring into operation replacement VHF aerials carried on a 680-ft triangular section lattice steel mast. The decision to proceed with this mast was taken on 25 March and construction and testing was completed in 22 days, despite time lost due to gale force winds; this new aerial brought into operation on 16 April provided satisfactory VHF coverage to virtually all viewers previously able to receive Emley Moor. Earlier, the immediate measures taken to minimize problems arising from the collapse of the mast included the erection, under unusually severe weather conditions, of a 200-ft 'zip-up' emergency mast carrying a wideband aerial, brought from the ITA Lichfield station. This temporary aerial was brought into operation on 23 March, a few hours before a new 100-watt e.r.p. relay station also began operation at Sheffield. This relay station was installed at a BBC site in just over two days, following a feasibility study carried out on 21 March.

Fortunately, no injuries and relatively little damage to buildings were sustained during the collapse of the 1265-ft mast. Questions relating to the cause of the collapse, and the avoidance of such accidents with other tubular steel masts, formed the subject of an intensive investigation by an independent commission of inquiry. As a matter of urgency, the ITA's experimental and development laboratories developed a full instrumentation system for tall radio masts, and a number of modifications were made to ITA masts at Belmont and Winter Hill. The final report of the independent commission of inquiry is still awaited.

Arising out of the collapse of this mast the ITA subsequently began construction of a new 1080-ft (14,000-ton) aerial support tower at this site. To the 900 ft level, the tower, now nearing completion, is a self-supporting reinforced concrete structure–the first time that a high tapered concrete tower has been built in the United Kingdom to carry television broadcasting aerials. It is expected to be about the third highest structure of its type in the world, concrete towers for television having been built in Moscow and East Berlin.

The concrete tower has a base diameter of 80 ft tapering to 20 ft diameter at 900 ft where there is to be an enclosed room equipped as a microwave link station for outside broadcasts. This will be surmounted by triangular lattice steel sections carrying the aerials to an additional height of 180 ft. The top lattice 80-ft section, carrying the UHF aerials, will be encased in 5-ft diameter cylindrical glass-reinforced plastics covering, and the lower 100-ft lattice section, carrying the VHF aerials, will be mounted within a 12-ft diameter g.r.p. covering.

The concrete tower will weigh about 10,750 tons; the foundations about 3200 tons: a total weight of almost 14,000 tons.

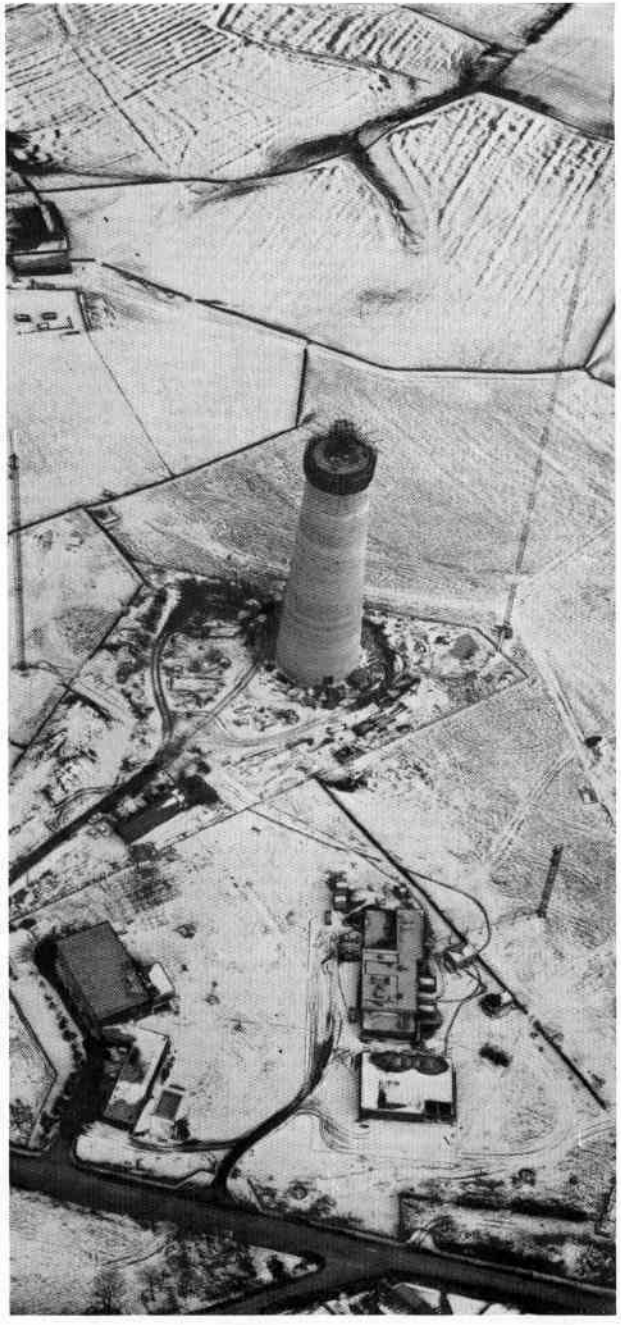
Although this form of concrete tower, to this height, is significantly more expensive than a stayed tubular mast, it was considered that it could be completed much more quickly than any possible alternative, and should prove more pleasing aesthetically.

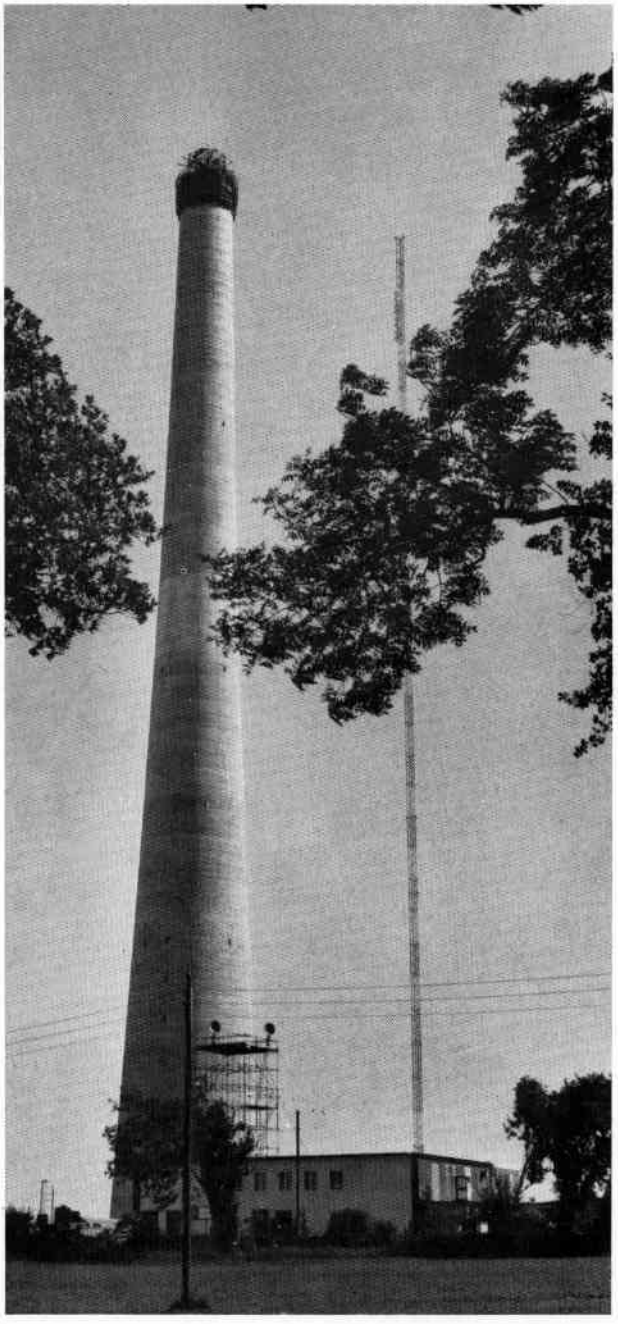
Work on the foundations for the new tower started in July 1969; it is anticipated that the tower will be complete this Autumn and the UHF aerials brought into operation early in 1971, with the VHF aerials following a few months later. The tower will carry ITA VHF and UHF aerials, and the UHF aerials will also be used for BBC1 and BBC2.

The wreckage of the 1,265-ft Emley Moor tubular mast which collapsed on 19 March 1969

Below: The start of the race to build the 200-ft 'zip-up' mast which restored Independent Television to Yorkshire viewers in under four days. ITA riggers and aerial engineers worked for more than 36 hours non-stop during the first phase despite sub-zero temperatures

Right: The new Emley Moor concrete aerial-support tower as the height reaches over 700 ft. The steel lattice tower alongside is the temporary VHF aerial mast installed in under one month. When complete the concrete tower will be to a height of 900 ft and will be surmounted by a further 180 ft steel lattice section. Tower weight of the concrete structure including foundations will be about 14,000 tons.





28 Keeping the Trade and the Public in the Picture

It was appreciated that an important requirement for the successful introduction of the 625-line duplicated colour service would be to ensure that the industry, the trade and the viewers were provided with the information which would allow them to understand exactly what was being planned, and how they could best make use of the new services. It was evident, for example, that many viewers and some dealers were under the impression that, with the coming of colour, Independent Television would be starting a new second programme channel. Considerable effort thus had to be put into channelling information on the technical plans and programme to those who would need to know. A new Engineering Information Service was set up to provide this information in the form of publications, leaflets, technical press releases, exhibitions, and at meetings of television suppliers and aerial erectors. Regional and local liaison has also been strengthened by the appointment of three Regional Engineers and their staffs, though these are primarily concerned with the operation of the transmitter networks in their regions.

With the start of the first test transmissions, it also became clear that many viewers needed further advice on aerials and on reception problems that sometimes arise. At the same time, the Engineering Information Service participated in a series of travelling exhibitions–'The Colour Television Show' in collaboration with the British Radio Equipment Manufacturers Association, the RTRA and the BBC. These exhibitions explained the significance of the opening of three-channel 625-line colour transmissions to more than 145,000 viewers at five venues. It was also found that exhibitions and dealer meetings provided valuable feedback of information on the views and problems of the industry and trade, and of the viewers.

While experience has shown that the vast majority of receiving sites within the predicted service area of a three-channel, co-sited UHF station are able to obtain satisfactory pictures from all channels, there are occasional problems in achieving equally good 'ghost-free' pictures on each of the three channels. Another problem arose from the susceptibility of some distribution amplifiers to overloads from new stations. In all cases, the co-operation of the aerial and equipment manufacturers has brought rapid amelioration of the difficulties, but the requirement for good outdoor aerials and the use of low-loss co-axial feeder cables has to be brought home to viewers on every possible occasion. The smooth radiation patterns and good wideband performance of log-periodic receiving aerials can often provide satisfactory reception at difficult sites.

Television Gallery

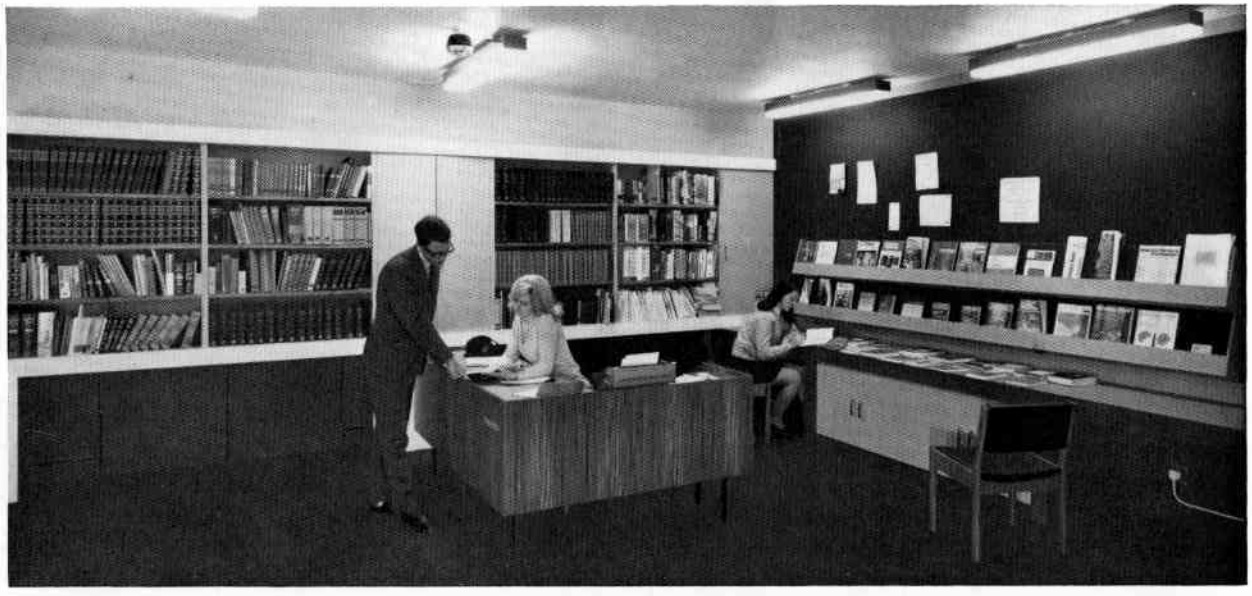
Engineers interested in the history of television, or about the way in which television has developed not only in the United Kingdom but also in many countries, are invited to visit the Television Gallery at ITA Headquarters, 70 Brompton Road, London SW3 (Telephone 01-584 7011, extension 470).

The Authority has planned and built this fascinating gallery as an information centre covering the whole story of television, past and present. By means of ingenious visual displays it shows the history, the state of television in the world today and how programmes are devised and produced.

The Television Gallery is open to the public by appointment during office hours, and by special arrangement for groups.

Associated with the Television Gallery is the ITA Library, including many engineering texts, and Reading Room, available to all with a genuine interest in television.

Part of the ITA reference and engineering library at Brompton Road–the library is available to all having a serious interest in television



29 Research and Development

The ITA Experimental and Development Department is based at Brompton Road, where both offices and laboratories are located. The staff employed at present number about 60.

The development work is divided among three sections:

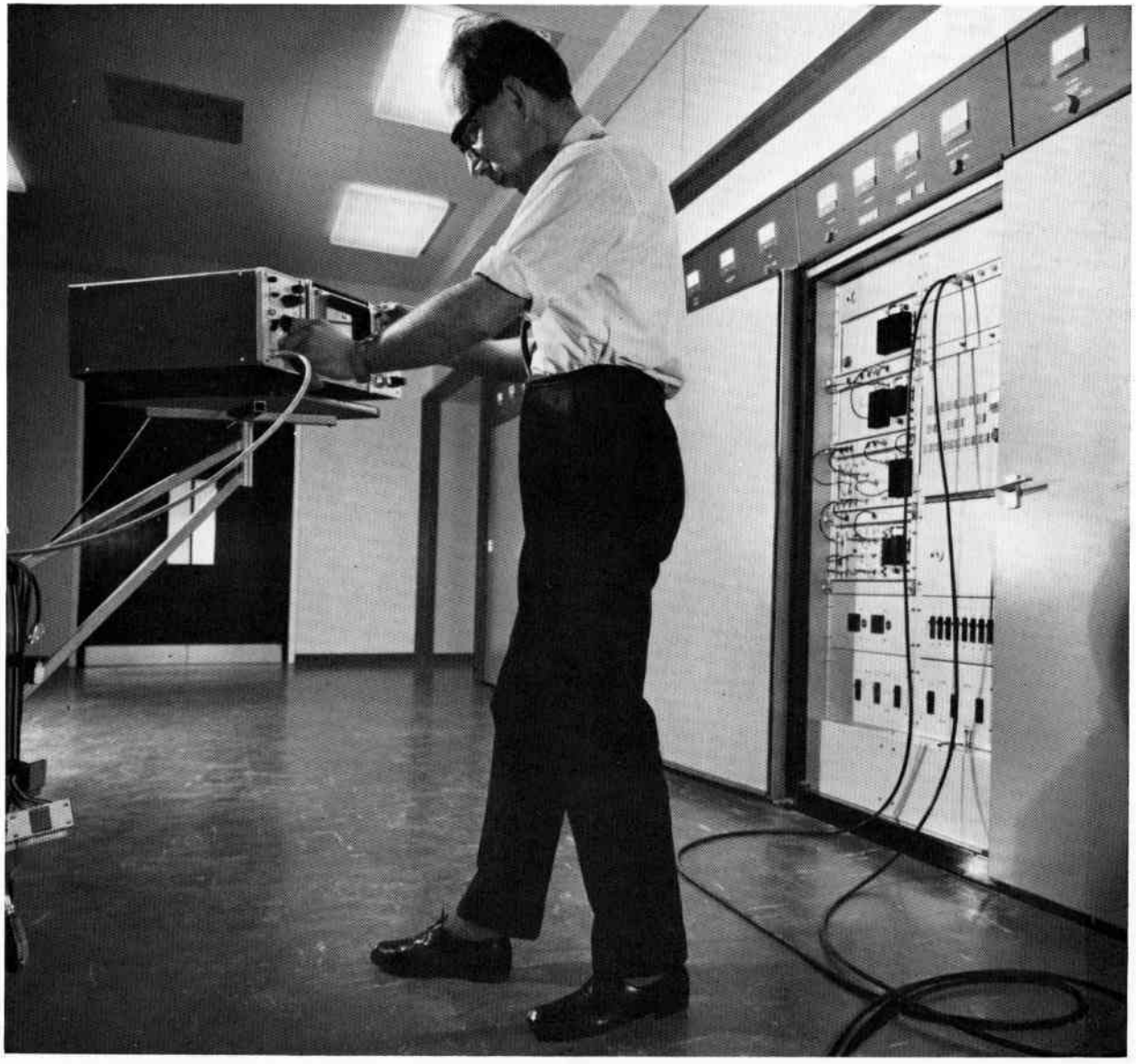
The *Radio Frequency Section* deals with high frequency work mainly in the field of specialized receivers, demodulators, filters and test transmitters. This section recently developed a full instrumentation system for tall radio masts.

The *Video Section* is concerned with video and colour development, and its work is, in many respects, similar to studio engineering, although it rarely deals with problems which are directly associated with the television camera.

The *Automation and Control Section* deals with any matters in the field of telemetry, control and automation. It is currently working on questions of applying general purpose computers to television transmitter networks.

Also within the Experimental and Development Department is the *Engineering Services Section* which provides the engineering support services for the development and production activities of the department. It operates a modern, well-equipped drawing office and workshop, capable of carrying out the necessary design and manufacturing tasks associated with the development of modular electronic equipment and precision mechanical assemblies. Production equipments are tested, aligned and prepared for service by a special Test Group. The activities of the section are regulated by a Project Co-ordination Group which is responsible for liaison with customers and for the preparation of schedules.

In the Crystal Palace transmitter hall



30 Insertion Test Signal Equipment

An insertion test signal system has been developed by ITA which generates and inserts a set of test line signals into the field blanking interval of a television signal in such a manner as to accommodate differences between the various test line signal standards, and to allow for possible future changes. The generator can be readily re-programmed by simple wiring and component changes.

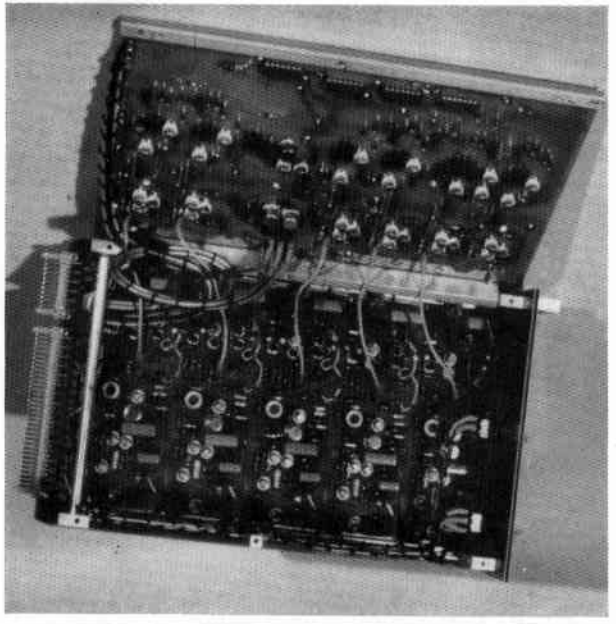
Test line signals are now widely used for monitoring and automatically controlling the performance of monochrome television channels during transmission time; for colour television an extension of the test signal is needed to monitor additional critical parameters. Although some measure of agreement has been reached on the recommended format of international and national test line signals, these are not necessarily identical nor inserted on the same lines.

It has been considered desirable to have one basic generator which could be easily adapted or 'programmed' to produce either the international or national signals, and also to cater for possible changes in the agreed standards.

While it would be feasible to generate continuously each of the four test line signals and then insert one into the main video signal by means of video switching circuit in an associated test line signal inserter, this would require a separate video switch for each test line signal.

The system adopted by ITA is to generate each of the signals 'on demand' by means of demand pulses generated in the test line signal inserter. The four signals may then be fed as a time sequential test line signal in a single output circuit. The on-demand system eliminates the possibility of test signal components breaking through on to the main video signal during picture time. Although, with time sequential operation, the signals controlling the generator become more complex, the co-axial circuits linking generator and inserter are reduced in number. A further module permits the generator to be operated in a self-standing mode, with the test signals having the correct relative timings necessary for proper operation of measuring equipment.

The realization of this ITA-designed insertion test signal equipment, including generator and inserter, has been described in detail in a paper: 'Insertion Test Signal Equipment' by J Schaffer and I Lever, IERE Conference Proceedings No 18, 'Joint Conference on Television Measuring Techniques.'



Above: The ITA insertion test signal equipment with inserter unit shown above the generator unit

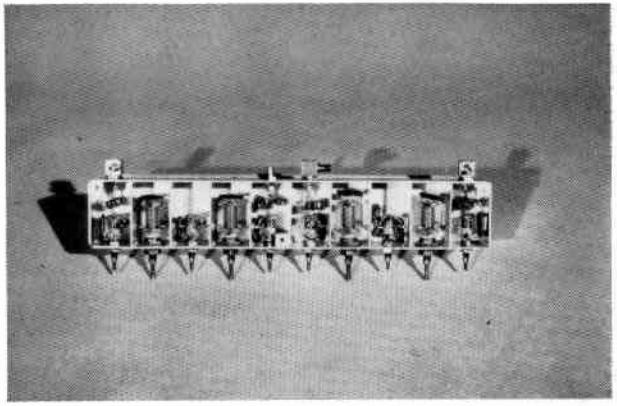
Below: Black-level stabilizers and high-speed switch used in the ITA insertion test signal equipment

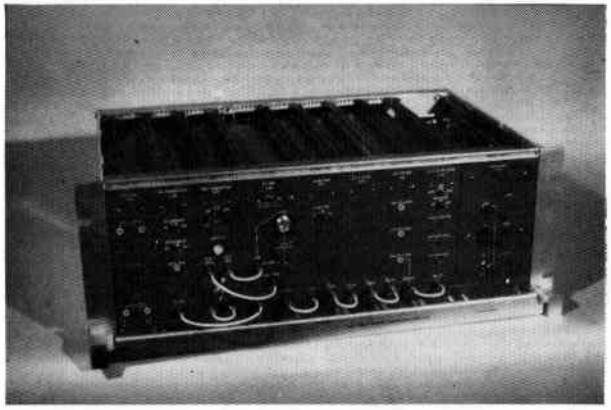
31 High Performance Receiver Techniques

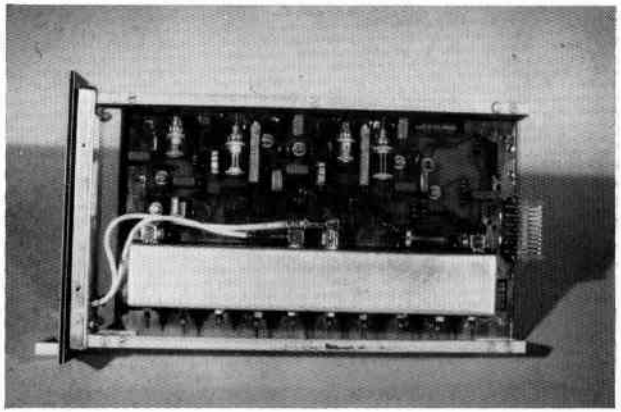
The requirement for high-performance receivers for such applications as rebroadcast links and for the monitoring of transmissions from relay stations has involved the ITA Experimental and Development Department in the investigation and development of a number of special demodulation techniques. For example, work on synchronous detection using phase locked loops has been carried out. The ability to lock an oscillator in phase with an off-air signal is important for several reasons: first, it forms the basis of a synchronous detector system in which the reference signal is derived from the received carrier, gated out during the sync pulse interval; secondly, the system provides a tool for measuring the phase stability of a received carrier and can thus provide data on jitter in propagation time caused by meteorological factors; thirdly, the system could be used for interference suppression where an interfering carrier may be cancelled by the addition of a locally generated signal of equal amplitude and opposite phase.

It has been the trend during recent years to employ waveform testing methods. Unfortunately, where vestigial sideband transmission is used, an inherent system distortion, normally referred to as quadrature distortion, takes place in a receiver unless synchronous detection is used. It seems likely that complex synchronous receivers will be deployed throughout the UK broadcasting networks in a few years time, but in the interim period techniques have to be used which allow the interpretation of waveform measurements in the presence of non-linearity during transient periods, even with perfectly adjusted systems. This may lead to operational difficulties, with the temptation to maladjust controls in an attempt to compensate for quadrature distortion. A number of proposals have been made by ITA engineers to improve the interpretation of waveform measurements made with existing non-synchronous demodulators.

High-performance 625-line UHF receivers have been developed by the ITA, making use of varactor multipliers and integrated circuit crystal oscillators, printed circuit UHF filters, crystal filter sound trap, IF modulation in the inbuilt UHF test transmitter and the facility of both direct and inter-carrier demodulation of the FM sound signal. During the course of the development programme, special attention was paid to the problem of achieving good linearity in the vision detector and in the associated test transmitter. It was also necessary to refine further, techniques already developed for i.f. group delay equalization, and to determine the best compromise between chrominance and luminance waveform characteristics.







Top: Vestigial sideband filter for the new 625-line demodulator unit

Middle: The newly developed ITA type E131 demodulator

Below: VSB filter and equalizers

32 Application of General Purpose Computers to the Control of Transmitter Networks

The future application of general purpose computers to the operation and control of large television transmitter networks has been outlined in a series of papers by ITA engineers, including an introductory description at the 1970 Fleming Memorial Lecture of the *Royal Television Society*, presented by Howard Steele, ITA Director of Engineering.

An experimental computer system, now being assembled at the ITA engineering laboratories in London, is part of a feasibility study to investigate the automatic surveillance by computers of the performance of entire regional networks of transmitters and links.

Current work is being undertaken with a view to applying general purpose computers to the problems of automatic monitoring and controlling networks and improving the information flow. Suitable computer programs are being written. Nevertheless, it is not expected that this study will result in fully automated performance monitoring of transmitter networks. Visual monitoring in manned control centres is expected to continue into the foreseeable future, owing in part to the mandatory requirement of the Authority to supervise certain aesthetic aspects of picture quality not yet amenable to automatic measuring techniques.

The main impact of automation is seen in the automatic surveillance of the performance of transmitter networks once the signal has passed normal quality control functions in the 14 new regional manned colour control centres which have been established for the networks of unattended UHF transmitters in each of the Independent Television regions.

But the future use of computers in the network will not be confined to transmitter automation. Storage and analysis of data, collation of information and the production of reports, the initiation of immediate, medium-term and long-term action, including management action called for by automatic assessment of reports are all anticipated.

The new performance monitoring techniques are based on computer analysis of vertical interval test signals (ITS) using sine-squared and flat-top pulses.

Current conventional measurement practice involves the manual use of oscilloscopes fitted with special graticules. For some years, ITA have also used specially-developed equipment which allows a slow-scan read-out of broadband interval test signals to be made over switched, public-network or private leased Post Office lines.

The new techniques will involve feeding digitized test signals immediately into computers which will then provide read-out of the 'K-rating' and other parameters.

Present studies envisage a sampling rate of approximately 13·3 MHz, equal to the third harmonic of the colour subcarrier.

Since it is wished to monitor relay stations as frequently as possible, it is intended that the necessary software should be optimized before a start is made on a fully operational protoytpe system.

As part of the experimental system, a computer with a 12K word store, teletypewriter, paper-tape punch and reader, disc backing store, and fast analogue-digital converter has been installed at the ITA laboratories. A cathode-ray-tube visual display unit and keyboard are being added.

To achieve good colour quality, there is continuous need to record performance, to compare this with a standard, to record trends and to correct adverse effects. It is believed that many of these tasks can be carried out by machines; it has been stressed, however, that any approach to automation should include a careful assessment of the effects of the proposed system on station engineers.

As soon as a decision was made to investigate the use of general purpose computers at control and monitoring stations, it was necessary to find the expertize in computer techniques that such a study would demand. The view was taken that the correct approach to this was to widen the knowledge and experience of electronic engineers rather than to attempt to teach computer experts about broadcasting engineering. It is considered that the success of these projects depends upon availability of staff with skills in both these areas.

Early in 1970 a 'management information' computer system was installed at the ITA headquarters, and close liaison has been established between the data processing group concerned directly with the system and the group currently studying the problems of control station automation.

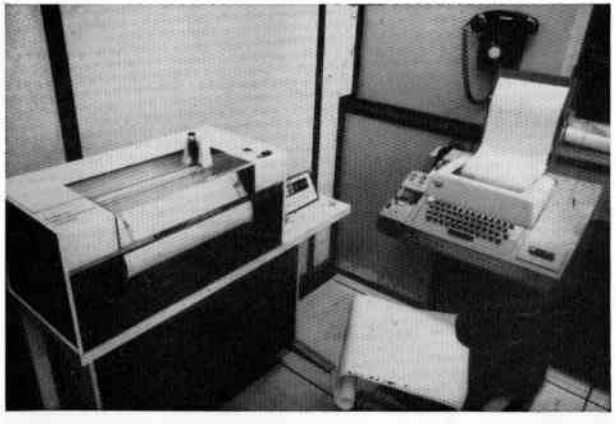
An experimental computer system for control station automation is now in operation. It is intended to add a cathode-ray tube 'visual display unit' and a keyboard to make studies of the man-to-machine interface. The final part of this work is expected to lead to a full specification for a field trial system.

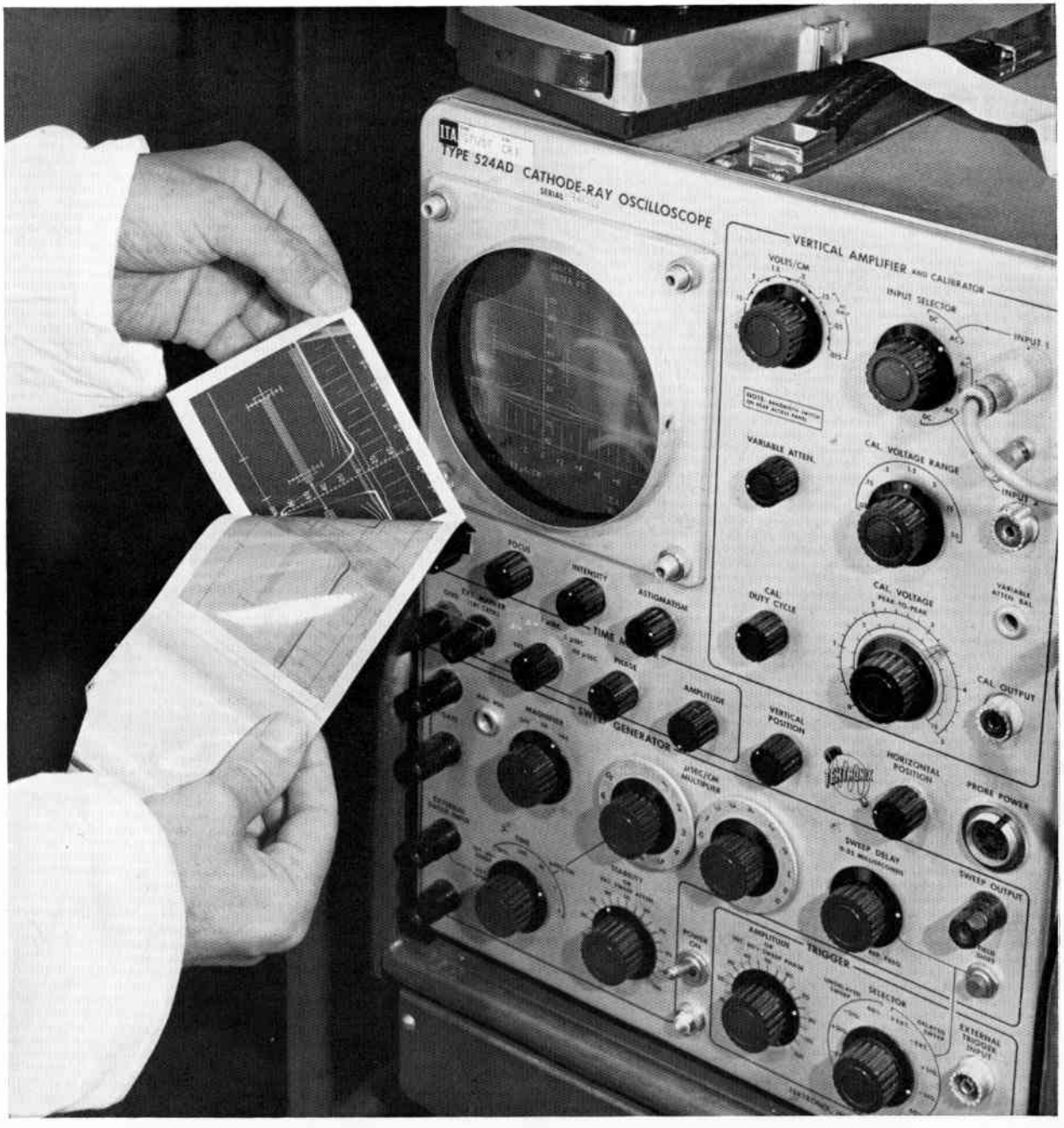
Currently, the major activity is directed at the development of programs which will allow the computer as far as possible to control operations at monitoring stations.

It is recognized that the concept of 14 control and monitoring stations supervising an extremely large transmitter network is central to the need to use digital computers in the television engineering operations of the ITA.

Right: The current technique for producing transmitter test reports is to take a 15-second Polaroid trace recording of a 2T pulse from which the K-rating can be calculated. In future many of these operations may be automated.

Below: Part of the ITA computer room set up to investigate the use of general purpose computers in the control of large transmitter networks





34 Instrumentation System for Tall Transmitting Masts

A requirement to investigate the structural behaviour of tall transmitting aerial masts led ITA engineers to develop a system which would provide detailed measured data of the behaviour of such masts. The system also provides hazard warning for station staffs.

The construction of certain types of tall, cylindrical aerial masts is such that during unfavourable wind conditions oscillations occur at a frequency of about 1 to 2 cycles per second, and with the maximum magnitude of the acceleration forces about 0·3G. Additionally, some static tilt may be expected, particularly due to asymmetric ice loading conditions; an indication of wind speed and direction is necessary in order to correlate the data with weather conditions.

Initially, a basic instrumentation system was installed which could provide an alarm system under hazardous conditions; this consists of three accelerometers mounted in the lattice sections installed on top of the 9-ft diameter steel supporting cylindrical mast, at heights from about 700 ft to about 1000 ft. These accelerometers trigger an alarm when the acceleration forces exceed 0·15G or the static tilt exceeds 2°. An additional alarm parameter is a wind speed at a height of 10 m, greater than 60 mph. Strain gauges are located at various heights from about 450 ft upwards; at each strain gauge location there are three measurements taken at 120° around the shell or on the three triangular legs of the lattice.

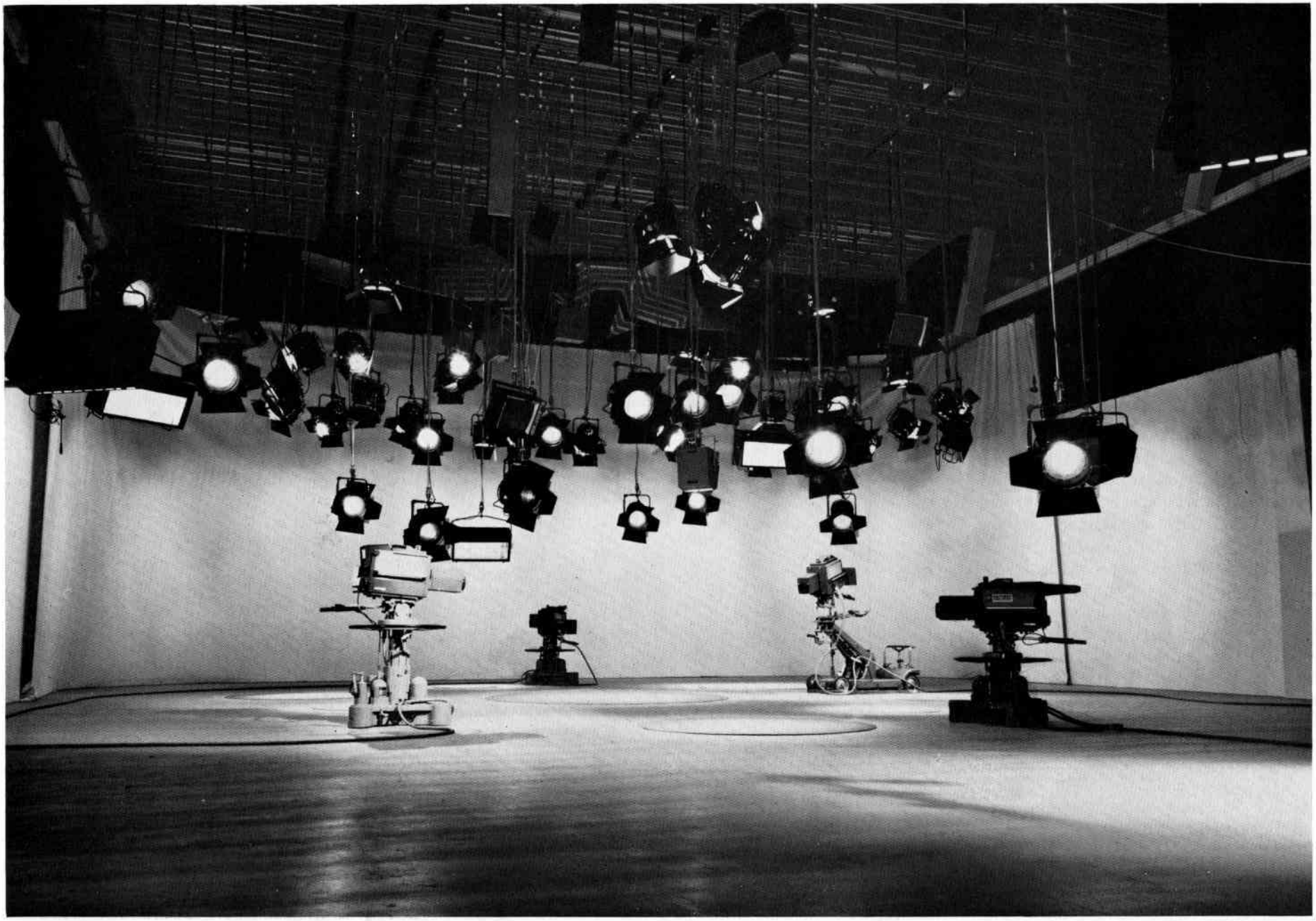
Electrolevel transducers are used, these being a simple device consisting of a fluid electrolyte enclosed in a spirit level tube. Three electrodes are enclosed in the tube and the resistance ratio between the centre and the two end electrodes depends on the position of the air 'bubble' which in turn depends on the attitude of the device. Care had to be taken to control the environment due to temperature and r.f. field effects. Two such devices, orthogonally mounted, are used at each level, each tube being used to form the two arms of an ac resistance bridge, the unbalancing signals being amplified at source and further processed at ground.

The use of a simple spirit level as an accelerometer may seem surprising until it is realized that the angular deflection from the horizontal is no more than the resolution of the vertical acceleration due to gravity. In addition to the original accelerometers, four further units have been installed to provide full instrumentation with 15 strain measurements.

The outputs are used to obtain tilt and displacement information in addition to acceleration, and are available for recording on magnetic tape.

A mast instrumentation system has been installed on this 1,265-ft mast at Belmont

Studio 1 (6,000 ft²) at Southern Television's new £2½ million colour studios at Southampton



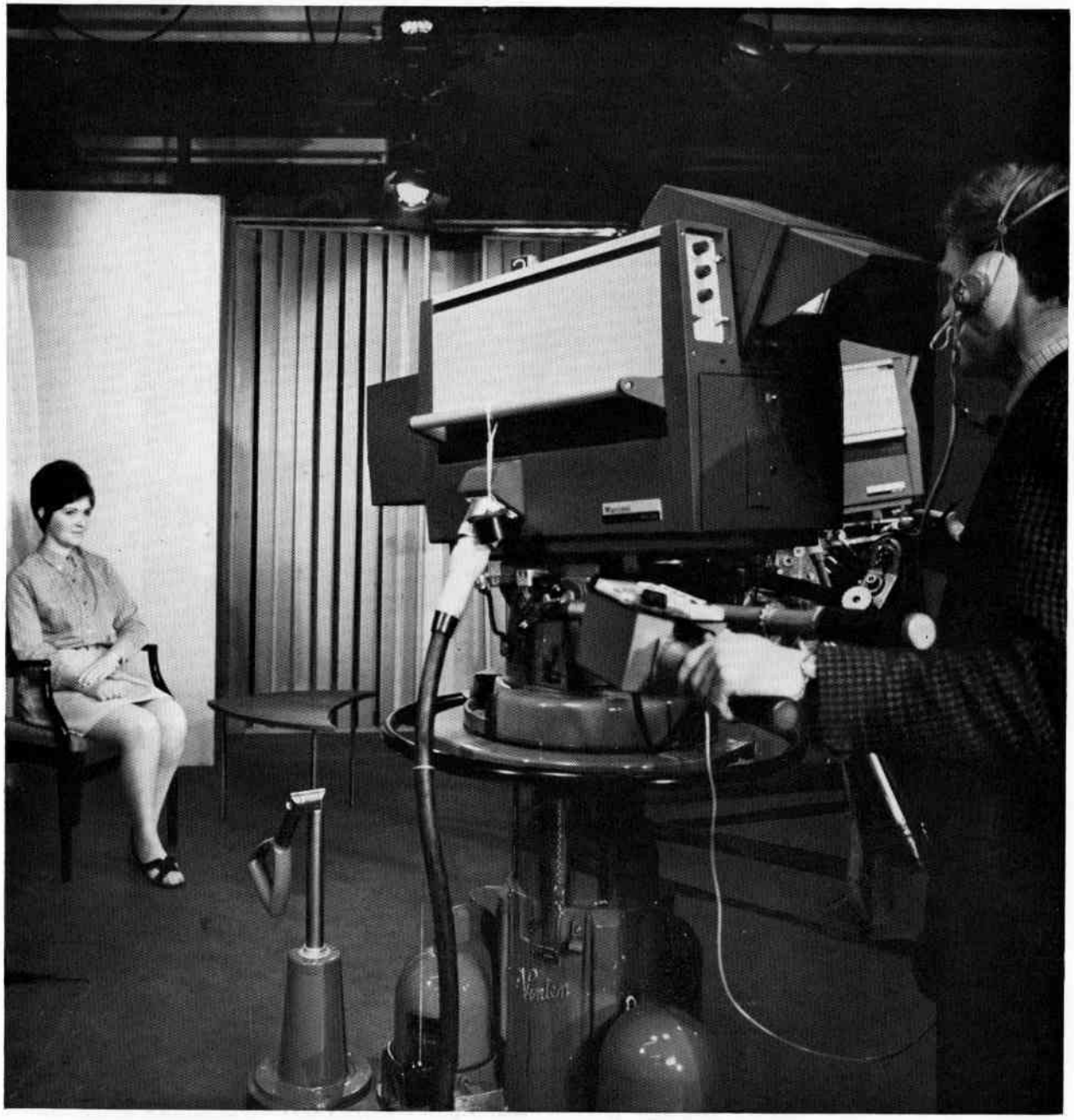
36 Independent Television Colour Studios

The problems of launching into colour have been shared by all those involved with Independent Television–the programme companies, the Post Office who supply the inter-city links and the Authority.

The change to 625-line operation, and–in many cases–the early requirement for colour, has involved the programme companies in major re-equipment and conversion projects. As a result of the federated regional structure of ITV, the companies need appreciably more production and studio facilities than would be required for a monolithic broadcasting organization. It has been estimated that there are now working, or soon to be commissioned, some 187 colour camera channels, 60 colour-capable video tape recorder machines and some 76 colour-capable telecines.

Among the many major undertakings by the companies have been the establishment, either by conversion or by completely new studio complexes, of some 40 colour studios and about 15 colour outside-broadcast units. Further centres are expected to become operational over the next few years.

Imaginative planning and novel conceptions have been employed by London Weekend in converting their Wembley Studios; this company is also building, over the next few years, a new studio centre in the King's Reach between Waterloo Bridge and Blackfriars Bridge on the South Bank of the Thames.



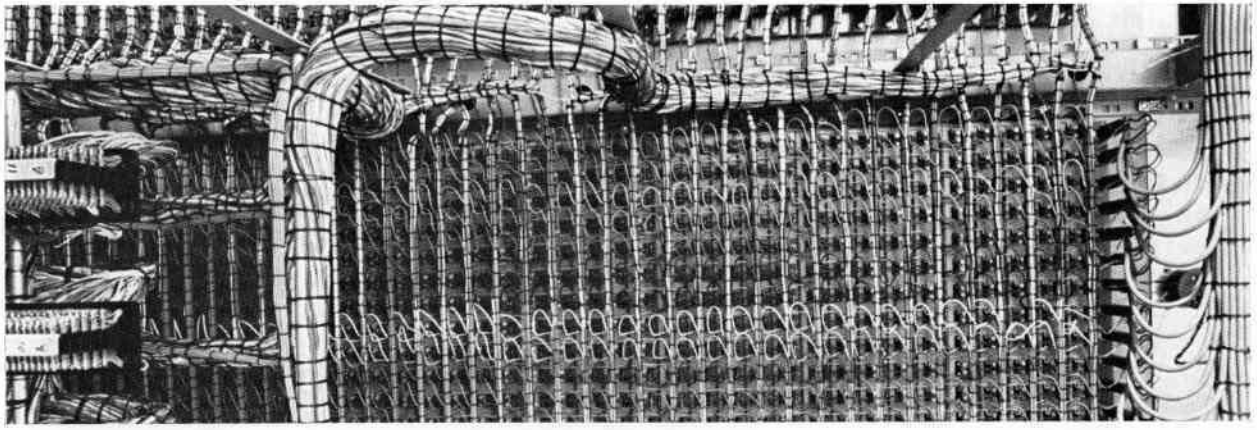
In the period before the launching of colour in some regions, programme contractors set up experimental colour studios–this is a Tyne Tees studio equipped with two Mark VII colour cameras

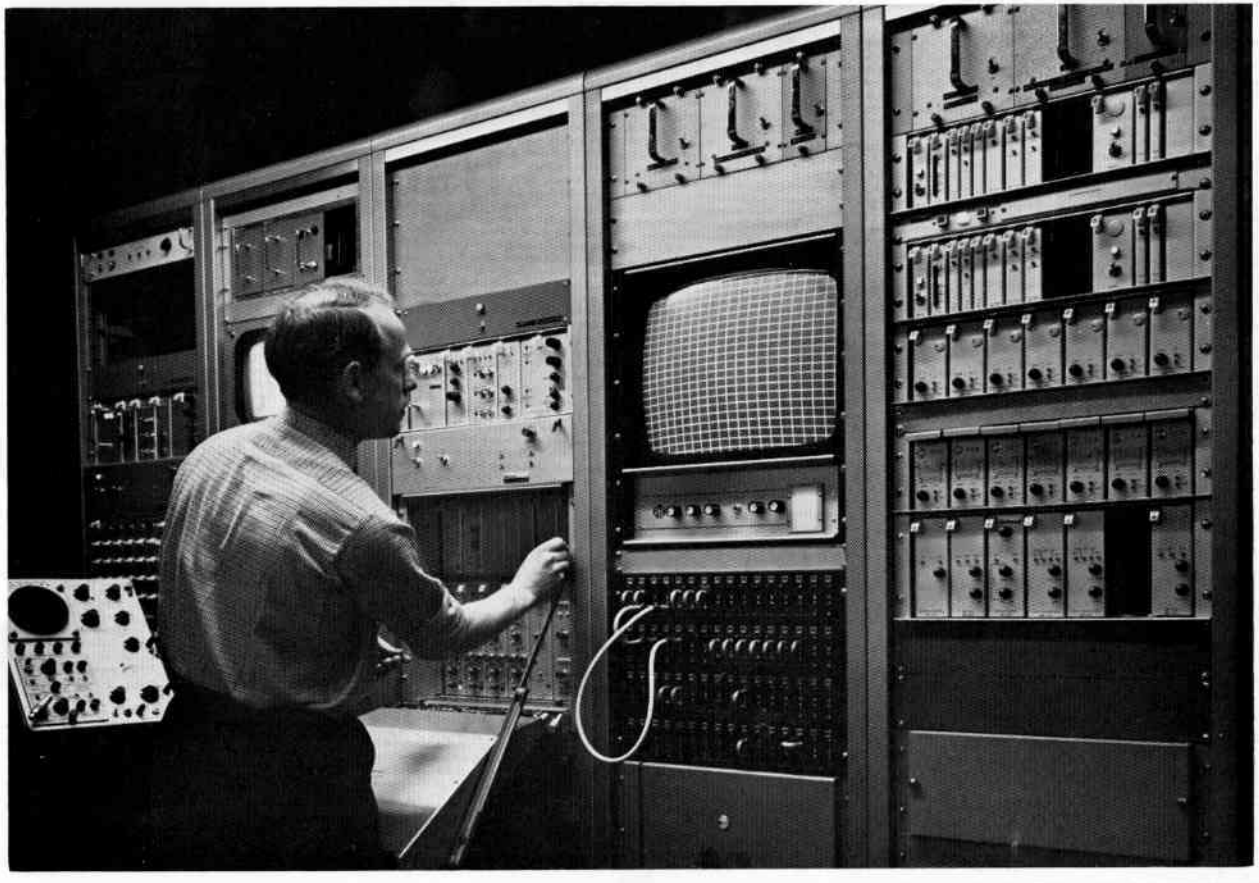
Thames Television are completing a new studio and administrative complex at Thames House, part of the Euston Centre development close to the Post Office Tower. This facility became operational in 1969 and includes two main colour studios. A feature is the use of computer-aided master control switching whereby the man at the control desk remains in full charge of the initiation of complex switching operations which are then carried out with the aid of the computer. Thames also undertook a major conversion of their Teddington studios for colour operation.

Southern Independent Television has completed a new three-storey studio complex, on land reclaimed from the River Itchen, at Northam, Southampton. The new centre has four studios: 6000 ft², 3000 ft², 1200 ft², and 350 ft². It is described later in this publication.

The jointly-owned Independent Television News, after many years in Television House, Kingsway, moved overnight to the new ITN House, a ten-storey headquarters building on the corner of Wells Street and Riding Horse Street, London, close to the Post Office Tower.

The first of the new purpose-built colour centres was that for Yorkshire Television at Leeds which became operational in mid-1968. The following year, the company extended and completed this studio complex which incorporates production and technical areas, together with administrative offices, in a self-contained unit. All the technical equipment has full colour capabilities. The largest studio is 7650 ft² and is furnished with five four-tube colour camera





Above: The complexity of a communications matrix–part of the many bays of the matrix at London Weekend

Below: Engineer checking registration of a colour camera at the Yorkshire Television centre at Leeds

Right: Part of the new facilities for ATV at Birmingham

Centre left: The Telecine Control Desk, part of the Central Apparatus Room, at Southern Television's new colour studios at Southampton

Centre right: In preparation for colour, which Anglia will launch at the beginning of October, the main programme production centre at Norwich has undergone a major reorganization, technical areas being systematically rebuilt and re-equipped. This shows part of the new studio production control unit

Below left: Production control for Studio 5 at the new Thames Euston centre

Below right: Tyne Tees Production, vision and lighting control suite for Studio 1

channels. The studios are equipped with computer-type lighting control with luminaires. The central apparatus room includes six telecine machines of which three are twin lens flying spot types and three multiplex Plumbicon units.

ATV Network built a new colour studio centre, including 11,000 ft² of studio floor space, as part of a large new entertainment complex: ATV Centre, Birmingham. The three major production studios have areas of approximately 6000 ft², 3250 ft² and 1680 ft² plus a general purpose and interview studio of 350 ft².

New studio control rooms, master controls, central apparatus rooms were installed by Granada as part of a major colour conversion at the Manchester centre.

The conversion of the Theatre Royal in Glasgow for colour operation and a new colour studio in Edinburgh were undertaken by Scottish Television.

Colour facilities were provided at Norwich by Anglia Television during 1969 in readiness for colour programmes in the region from Autumn 1970. A major reorganization of the Norwich centre included the systematic rebuilding and re-equipping of each technical area. Technical facilities have been centralized; studio A within Anglia House converted for colour, and a new master control area completed.

Tyne Tees Television brought colour facilities into operation in 1969 to provide colour experience and to train staff for the extension of colour to their region in Summer 1970. Electronic memory lighting control and a reconstruction of many of the technical facilities was undertaken, and an ME4 colour processor for newsfilm installed.

Colour Outside-broadcast Vehicles

Many of the programme companies, working in close collaboration with industry, have commissioned new fleets of colour OB vehicles. Representative of these vehicles is the five-camera unit built by EMI Television for Granada. This is mounted on an extended Vauxhall Bedford KMH chassis with an overall length of just over 30 ft. The vehicle is divided into separate control areas for production, sound and vision. The vision mixing system provides up to a total of seven inputs, three of which can be either synchronous or non-synchronous, and includes special effects. A caption-scanner located in the cab area folds back into the wall when not in use. The vision-mixer is of the AB/CD type. The sound area contains a 24-channel, six-group mixer with echo foldback and pre-fade listen facilities, together with a reel-to-reel tape-machine and two cassette machines. The cameras (five EMI 2001) are contained in glass-fibre boxes which are carried in waterproof lockers. A four-wheeled trolley for carrying the cameras is also stowed in a locker. Picture-display facilities for production control include colour monitors for both preview and transmission circuits, with monochrome monitors for other sources.

A four-camera colour OB unit is operated by Scottish Television; two Marconi OB vehicles each capable of up to four Mk VII cameras by Yorkshire Television; two colour-capable OB vehicles are in use by ATV Network; the Thames OB facilities include two four-camera units, a two-camera unit including VTR, and a one-camera plus VTR unit; Tyne Tees have a four-camera colour OB unit and a mobile VTR unit; HTV recently took delivery of a new EMI colour OB vehicle. A recent colour OB vehicle for Southern Television is described in more detail later in this publication, together with the conversion for colour of the unique OB vessel *Southerner*.

Left: Southern Television's mobile control room

Below left: Vision equipment racks and set-up area of a new four-camera (2001) outside broadcast vehicle built by EMI for HTV. It is 35 ft long and sub-divided internally to provide separate control areas for production, sound and vision with independent air condition in each area

Below right: Sound mixer and equipment rack in the sound control area of five-camera colour OB vehicle built by EMI for Granada

ITN House, the new headquarters of Independent Television News, was officially opened by the Queen on 20 November 1969. The new centre, in Central London, has been designed as a multi-standard 625-line/525-line, PAL/NTSC studio and film processing complex able to originate, record and replay programmes on either European or American standards. During 1970, field-store electronic converters, 525/625 NTSC/PAL and 625/525 PAL/NTSC, as well as SECAM/PAL transcoders, are being added to the facilities.

Independent Television News is a non-profit-making organization jointly owned by all the Independent Television programme companies, and provides the daily programmes of national and international news broadcast throughout the Independent Television network. ITN also produces programmes for individual companies and is a joint-owner of the UPITN international news-film agency. Many of the ITN technical facilities are available on hire.

The new headquarters includes two studios equipped with five EMI 2001 colour camera channels; four Ampex VR2000B high-band television tape-machines; a central apparatus room with Marconi machine-assignment switcher and master control switcher; film dubbing and preview theatres; sound transfer suite and film processing equipment including two ME4 colour-film processing channels.

The main studio (about 2000 ft²) is about 30 ft high, and there is a smaller interview studio (about 700 ft²). The large editorial newsroom is on the same floor as the VTR, telecine and main cutting rooms. Two large doors can be swung open to provide direct access from the editorial room into the main studio for combined use during major news events.

ITN House forms part of an eight-storey tower block, and has been specifically designed to meet the most modern requirements of television news reporting, and to be adaptable for the future developments in this area which seem likely during the 1970s. The centre has been designed primarily around the two key areas–the newsroom and the main Studio One. News staffs in the newsroom have close contact with the technical operation involved in news-programme production, including film editing, sound editing, tape editing, still-picture editing, graphic design and programme direction.

Most of the lower ground-floor is used for the film operations of both ITN and UPITN. There are three channels available for colour-film processing, and another for black-and-white operations. The main film viewing, cutting and dubbing area is located on the second floor, above the newsroom. There are three small theatres with a common projection area, and six cutting rooms in the same complex. The camera and lens maintenance workshops are equipped to service Arriflex, Auricon and Bell and Howell cameras, and all types of lenses.

The building also houses other broadcasting centres, including the Scandinavian Broadcasting Centre on the sixth floor. By means of the ITN control centre and the Eurovision permanent networks of leased international sound and television circuits, reports from these centres can be transmitted directly to the correspondents' home countries. The Scandinavian centre provides facilities for four broadcasting organizations: DR (Denmark), NRK (Norway), SR (Sweden) and YLE (Finland).

The new Rank electronic field store converter provides ITN with full 625–525 line interworking capability

41 Technical Developments at ATV Network

The first transmissions in September 1969 from ATV Network's new Birmingham Studio Centre represented the culmination of a two-year programme of planning, building and installation. The centre, fully colour capable, comprises three studios, a presentation suite and technical areas and auxiliary facilities. The three main studios, totalling 11,000 ft², share ten four-tube colour camera channels. Studio One (5600 ft²) has a permanent audience facility seating nearly 200. The central technical facilities include six VTR machines, five 35 mm and two 16 mm flying-spot telecine machines. Major re-equipment and colour conversion projects have also been completed at the ATV studio centre at Boreham Wood, near London.

In this section a number of technical developments in which ATV Network have been particularly concerned during recent years are outlined briefly. Most of these have been described in more detail in the technical literature.

Scan Linearity Measurement

This work was initially undertaken by Alpha Television Services (Birmingham) Ltd although in recent years ATV have undertaken the supply of the special gratings used in this measurement technique. The technique was described by A J Henk, 'Scan linearity measurements without tears', *Wireless World*, September 1966.

The measurement of scanning linearity, whether for studio monitors or domestic receivers, is conventionally extremely tedious to perform, being based usually on generating a pattern of small squares or rectangles for display on the screen and either carefully measuring them with a ruler or comparing the pattern with a reproduction printed on a transparent sheet and held in front of the cathode-ray tube face; such techniques often prove difficult to use with any accuracy in practice. A quick, convenient testing method using optical interference patterns formed by video bar generator and convergent grating was developed and has established itself as a satisfactory means of assessing and measuring departures from perfect linearity in television picture monitors in terms of scanning velocity errors to a high degree of accuracy. The greatest advantages of the system are speed and convenience; the size of the raster, while it has to be approximately correct, is far from critical. Small departures from the correct setting result simply in a displacement of the pattern from a central position.

The principle used is that of optical interference (Moiré) patterns. An interference pattern is the visual effect produced when two regular fine structures are superimposed, for example, two pieces of silk. Both structures consist of alternate opaque and transparent areas, and when the opaque areas of one cover the transparent areas of the other there is little or no light transmission through the combination. When opaque areas cover opaque areas, the transparent areas also correspond and the combination transmits light as though only one structure were present. One of the structures can take the form of a light pattern on a cathode-ray tube, while the other can be a transparency held against the face of the tube, or its implosion guard.

In practice, a pattern generator is used to produce bars on the monitor screen; a transparency is affixed to the face of the tube by means of adhesive tape, with the lines vertical if line linearity is to be measured; or horizontal for field measurements. The display is observed by means of a mirror, and adjustment of scan amplitudes is made until the characteristic Moiré patterns are seen. In the case of line measurements small alternations in picture width cause the pattern to move up or down in the frame, a setting being selected to provide a more or less central position. If the setting is grossly incorrect the pattern will not appear.

Pattern interpretation may be a little difficult at first but familiarity comes quickly, after which only a quick glance will usually be necessary. Linearity controls can be set very quickly while the pattern is being observed, and small regions of non-linearity are as obvious as large areas. Provided that a few simple precautions are observed during setting-up, results are repeatable and consistent.

Audio Identification System

A system to enable identification of programme sources in the Independent Television Network by means of recognizing unique signals transmitted over the music circuits was initiated by Alpha and brought to fruition by ATV, equipment for the purpose now being supplied by ATV to other ITV programme companies.

The system was developed to meet the following requirements: to cater for up to 20 stations; identification should be unambiguous and fault conditions should, as far as possible, result in an indication which is obviously wrong and therefore not likely to lead to mis-identification; the frequency and other adjustments should not be critical, with conventional test gear adequate for setting-up purposes; the equipment should be economical and as uncomplicated as possible; the signals should be capable of being used for line-up purposes; there should be no possibility of obtaining misleading results should normal line-up tone be present on a circuit.

While the use of a single tone with a different frequency for each originating station is possible such a

system has a number of disadvantages. For example with 20 stations, 20 different frequencies would have to be allocated and the more difficult it would be to avoid allocating frequencies whose harmonics can fall within the passband of a filter higher up in the audio spectrum. Frequencies of 900 Hz, 1000 Hz, 1800 Hz and 2000 Hz must be avoided since these are related to commonly used line-up tones.

The use of combinations of frequencies overcomes these problems, and any extra complications are outweighed by savings in other respects when compared with the single-tone methods. The simplest combination is a pair, and the two-tone system has been adopted within ITV. Another possibility, which is felt to offer some further advantages, would be the three-tone system.

With two tones, to provide 20 pairs, only seven frequencies are needed; this means that the receiving station need have only seven filters and detectors instead of 20. In the case of three-tone combinations, 20 channels can be selected from 6 frequencies, so that a further filter is saved, although an extra oscillator is required in the sender. Each terminal would then require three oscillators whose outputs are combined in a common sending amplifier, six filters and tone detectors, a logic unit to identify the 20 combinations and a readout device which may be a lamp system. The output logic is contained in the readout (display) unit to reduce the number of conductors in the multicore cable connecting the detectors (bay mounted) to the indicators which are normally mounted elsewhere, often some distance away. A stability of 1 per cent is adequate for the sending oscillators; the frequencies are chosen to avoid harmonic relationships: a typical set of seven frequencies would be: 1000 Hz, 1120 Hz, 1260 Hz, 1500 Hz, 1680 Hz, 1890 Hz, 2120 Hz. At the receiving end a single-stage tuned filter uses ferrite cores.

The matrixing logic, for converting a three signal code to a single output signal can be accomplished by diodes, 60 being used in the form of 20 three-input 'AND' gates. Compared with the currently used two-tone system, a three-tone system has the advantage of inherently greater protection against ambiguous signalling.

Pulse Distribution System

Although pulse coding for the distribution of synchronizing and blanking waveforms along a single cable is now almost universally used in colour television studios, it is of interest to record that British Patent 1,052,948 of December 1966 (application date November 19, 1962) was issued to Associated Television Ltd (inventors K F Searle and L A Spong) for a coded distribution system. The object of this work was to provide a system which simplified the distribution of television pulse waveforms, particularly from a plurality of pulse waveform generators to the various positions in a group of television studios or other television picture generating units where they may be required. The patent specification indicated how pulse trains could be added in a simple manner to form a composite television waveform, with means provided at the positions at which each of the pulses are required for separating and/or regenerating the synchronizing and blanking pulses. Systems making use of the ideas put forward in this patent have since become commercially available.

Inter-area Communications Units

In common with other broadcasting organizations, ATV discovered that commercially available inter-area communications units, developed for very different applications, were often far from ideal. Although an area usually disregarded by television engineers, operationally it became clear that bad systems were the bane of the broadcaster's existence; good systems were hard to find. ATV, therefore, took the decision to produce units tailored to local, and in many ways special, requirements.

The system developed provides loudspeaking communication between all operational areas in the television complex, and is based on master-to-master working without slave stations. Each station has a microphone, loudspeaker and key box containing microphone and loudspeaker amplifiers, a number of miniature lever keys, input and output connectors, and a rechargeable battery. Signalling is by means of vocal announcement: the caller presses the appropriate key and identifies himself to the chosen destination. There are no buzzers, lights or any other calling devices. A 9-volt 250 mA-hour rechargeable battery is used, whose main purpose is to ensure the continued availability of the system in the event of mains failure. An additional advantage is that a complete system can be operated from a single power unit of relatively low output current capability, say 1-amp, via small diameter cables whose voltage drop is of little significance. A dynamic microphone is used; the loudspeaker amplifier has an output of 1-watt (adjustable) to 8-ohm impedance loudspeaker.

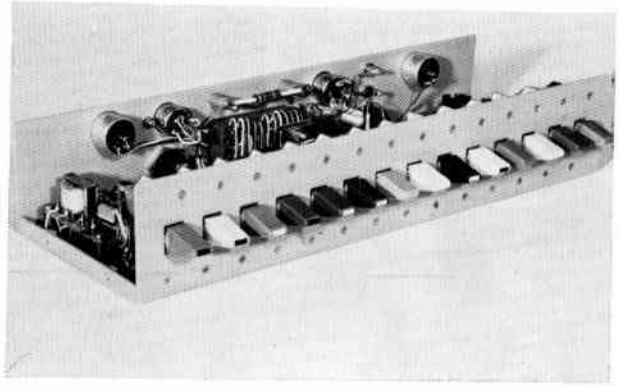
Telephone Cordless Switchboard

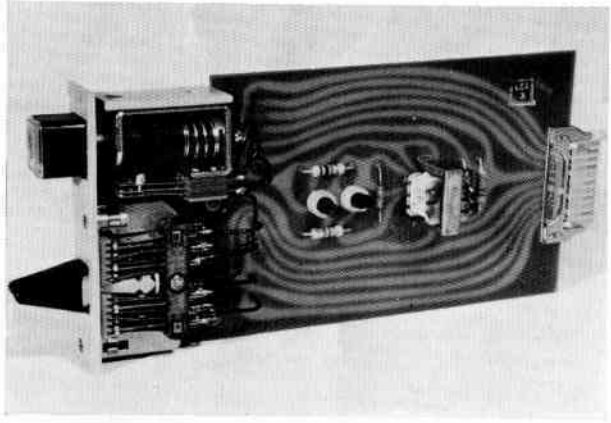
This has been developed over an extended period, for many of the same reasons as the inter-area communications unit. In its present form this is a cordless switchboard, detection of an incoming signal being achieved by a small solid-state detector/transistor switch in a plug-in ISEP module. The module also contains an illuminated push-button switch, which serves both to initiate ringing to line and also to indicate incoming ringing, and a miniature lever key which directs the call to one of two handsets (one 'up' and the other 'down').

Incoming 17 Hz tone is rectified, turning on the bistable switch, and hence passing current through the indicator lamp. The change of current drawn from the power unit is detected and used, via an amplifier, to operate a buzzer to draw the attention of the user to the incoming call. Operating the key to direct the call to the handset resets the bistable.

Above: Inter-area communication unit developed by ATV

Below: Cordless telephone switchboard module developed by ATV





As many indicator modules are used in each switchboard as there are incoming lines, and the modules are assembled in an ISEP $3\frac{1}{2}$-in. frame. The modules are extremely compact, the keys being on only 0·8-in. centres in the complete assembly. A further module contains a lever key which serves to extend an incoming line to one of two other switchboards.

Chroma-key Unit

Overlay by brightness separation has become a well-known technique in monochrome television, most special effects equipments being designed to operate in the self-key mode. In colour television, a rather more elegant technique, called Chroma-key, uses colour separation, the foreground artiste or object being set against a background of uniform hue and brightness, and of high saturation. It is essential that the foreground should contain no information of hue, corresponding to that of the background. This is difficult to achieve, and one way of improving the performance of the system is to be able to vary the hue of the background in order to obtain the maximum separation; this however requires that the unit which generates the keying pulse should have means for selecting the precise vector representing the background.

Early experiments at ATV were directed towards providing this facility, and some of the end results were judged to be remarkably satisfactory. Subsequent work in co-operation with local industry has resulted in the construction of equipments which are currently being installed in all ATV production studios, both in Birmingham and in Elstree. The prototypes have been used on many networked productions (e.g. Golden Shot, Crossroads).

The technique adopted is to feed the device with wide-band, pre-coder, RGB signals, and internally to select the appropriate proportions of these signals via a multi-position switch so as to enable the appropriate vector to be extracted. A fine control is used to interpolate between switch positions. Amplifying and clipping circuits are then used to generate a rectangular keying pulse which is fed to the output via a variable delay line, thus enabling accurate positioning to be achieved (the corresponding video having been delayed in the encoding process).

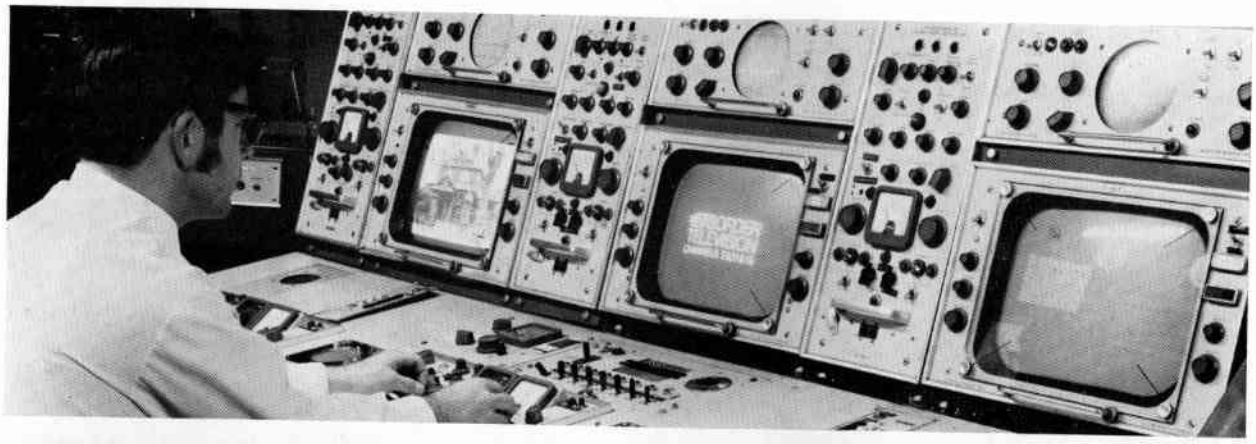
Variable Attenuator

An improved form of variable attenuator based on photo-resistive devices and light sources has been developed by ATV. Earlier arrangements of this general type tend to have poor stability owing to the fact that the resistance of the photo-resistive device is very sensitive to changes in temperature; there is also a disadvantage in the complex relationship between the output of the attenuator and the current flowing in the light source. The ATV attenuator has a second photo-resistive device, illuminated by the light source, and arranged to control the current of the light source. The two photo-resistive devices can be arranged at equal distances from the common light source and have similar characteristics, all in a common enclosure. The second photo-resistive device is connected as one arm of a bridge circuit, the output from the bridge being fed to a differential amplifier whose output controls the current through the lamp source. In practice, more than one attenuator device may be provided, to allow several signals to be controlled simultaneously: for example three attenuators may be used to control red, green and blue signals of a colour television system in applications where it is of great importance that the relationship of the three signal amplitudes be maintained accurately when controlling the output.

Border Television

Although Border Television is not due to start colour operations until 1971, in common with the other companies the studios have been converted for 625-line operation. Production facilities are concentrated at Carlisle in a building specifically designed for the purpose and including three studios (1050 ft², 645 ft² and 227 ft²). The two larger studios employ vidicon cameras and are served by a control suite designed and equipped by the company's staff. Solid-state production lighting control equipment can be made available in either studio through a specially designed power changeover system. In the presentation studio, a vidicon camera with remotely-controlled zoom lens and panning head is used.

For 625-line operation a new master control room has been completed and the mixing equipment now includes a 'memory' store. The augmented video tape section can deal with both low and high-band recordings. Telecine facilities are provided for 35 mm commopt, sepopt and sepmag and 16 mm commopt, commag and sepmag. Some 16 mm edge-stripe magnetic recording facilities are also used.



Above: Telecine control desk

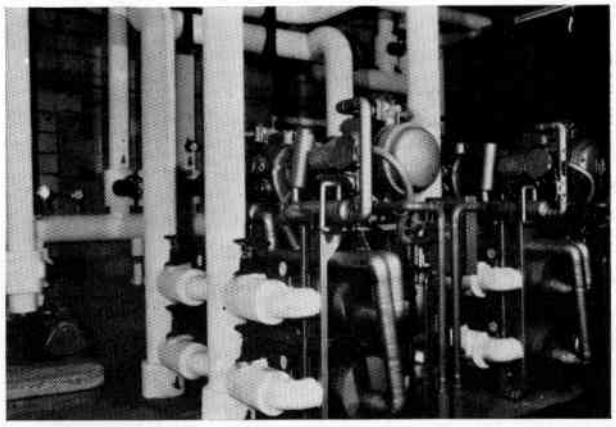
Below: Prevost film preview table: Dual 35/16 mm. Accepts Spools or Rolls up to 3,000 ft 3-speed operation, forward and reverse. Large or small screen capability

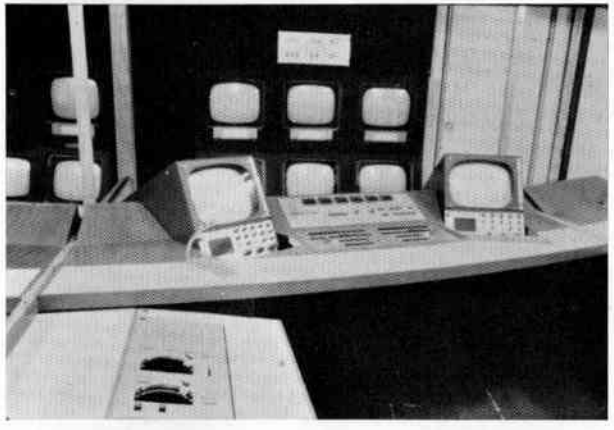
45 Granada Television

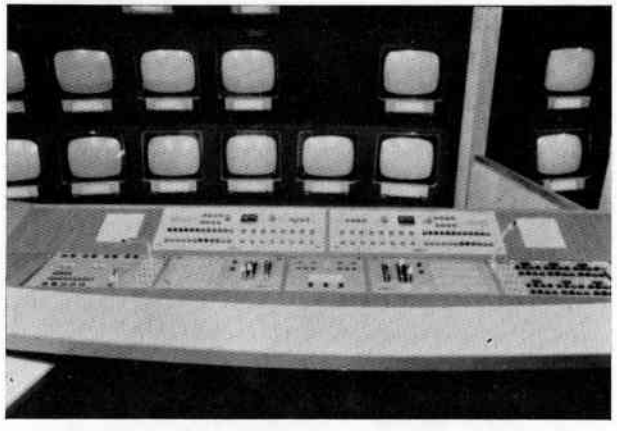
GRANADA

The Granada Television Centre was the first building in Britain specifically designed and built for television. It covers a five-acre site in the centre of Manchester, with an eight-storey administrative building topped by a 100-ft tower. With the approach of colour operations, a £3·5-million technical re-equipment scheme has made it a modern and efficient production unit for colour programmes. Granada has three large drama studios of which the largest has 8000 ft² of floor-space.

In this section, some brief examples are given of technical developments in which Granada has played a significant role.







Top left: New Technical Maintenance workshop established in preparation for the introduction of colour television

Top right: To maintain maximum stability of sophisticated colour equipment full air conditioning of all technical areas has been provided. The picture shows the central refrigeration plant at Granada Television Centre

Centre left: Network and engineering control room built to colour specification in advance of the colour service

Centre right: New transmission control switching centre built to colour specification in advance of the colour service

Below left: The photograph shows the colour tape editing suite with 2 high band colour tape machines on full-time editing duty. A production desk with simple sound and vision mixing facilities is shown in the foreground

Below right: The comprehensive monitoring and assignment panel installed in Granada's video tape recording control booth in preparation for colour services

Modular Floor Systems
False floors have been in use for complex technical installations for many years. To provide ease of installation and minimum signal paths for their colour operations, Granada Television installed one of the largest modular floor systems in the country. It utilizes cast aluminium tiles providing an accurate and almost water-tight fit. An illustration shows the colour apparatus room during installation.

Extensive use of Assignment Switching
Television Centres equipped with centralized telecine and video tape recording departments require facilities to route all the services associated with any facility, e.g. vision signal, sound signal, talkback, cues, remote controls, reverse picture, reverse sound and synchronizing wave forms, to/from studios, transmission control and the like. To keep signal paths to a minimum this is most conveniently achieved by a comprehensive switcher used at some central point with remote control panels in the areas concerned.

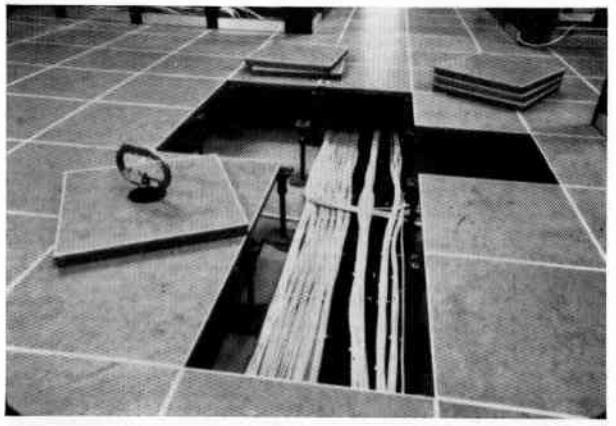
Granada pioneered this system with a remotely controlled assignment switcher as long ago as 1958. The illustration shows the comprehensive monitoring and assignment panel installed in Granada's video tape recording control booth, in preparation for colour services.

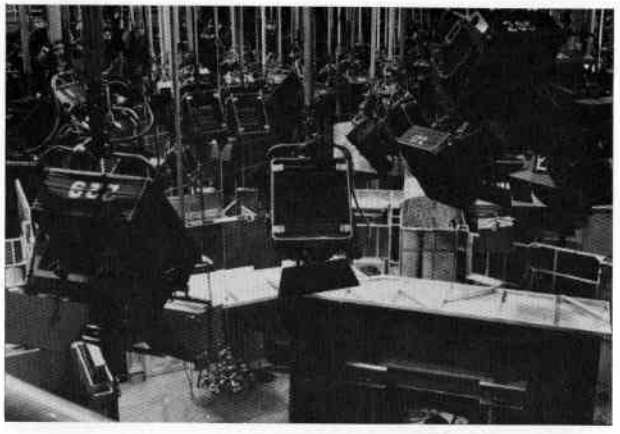
Grid Lighting Systems
Granada Television was the first television broadcasting organization to install a grid and telescope system of suspension for studio lamps (in 1956). The grid system allows individual positioning of each lamp in a studio area and reached added sophistication with the introduction of dual-purpose, dual-wattage luminaires in preparation for colour programming. An illustration shows a view of the 8000 ft² Studio 12 in the Granada Television Centre equipped with 300 telescope-mounted, identical lamp units.

Computerized Lighting Control System
Following consultation with various British broadcasting organizations, industry developed a lighting control system utilizing computer techniques. One advantage of computer type memories as employed in this system is the ability to set lamp intensity on a simple remote control panel directly from the studio set. The equipment memorises the lamp intensities which can then be recalled from the main control panel in the control suite.

The accompanying illustration shows the remote console in use to adjust the lamp intensity for a drama set in Granada Television's Studio 12.

Electronic Video Tape Editing
Granada Television pioneered the techniques of electronic tape editing in the late 1950s, before commercial editing equipment was available. The illustration shows the colour tape editing suite, with two high-band colour tape machines on full-time editing duty. A production desk with simple sound and vision mixing facilities is shown in the foreground.





Above: One of the largest modular floor systems in the country was installed by Granada Television for their colour operations. This picture shows the colour apparatus room during installation

Centre: A view of Granada's 8,000 ft² Studio 12 equipped with 300 telescope mounted identical lamp units

Below: The remote console being used to adjust lamp intensity in a drama set in Granada Television's Studio 12. (And the main lighting control panel in the control suite and equipment bays for the memory and processing units)

47 Technical Developments at London Weekend Television

LONDON WEEKEND TELEVISION

London Weekend Television took over the four television studios at Wembley Park, London in May 1968. These studios include Studio 5A and 5B which cover 7000 ft² each, and which can be converted into one large studio, making together one of the largest television studios in the world. Studio 1 comprises 4500 ft² and Studio 2 3800 ft². Before the company started transmissions on 2 August 1968, a new colour-capable Master Control centre was installed which also houses supplementary telecine and video tape recording machines. In readiness for the opening of the colour service, the company carried out extensive modification and re-equipment of the Wembley Studios, including the development of new techniques in the field of computerized lighting control and the development of new videotape editing processes such as positional reference recording. The company is also planning a new South Bank studio centre.

In this section, a number of developments stemming from London Weekend Television are described; several of these techniques are being marketed by the associated company Dynamic Technology Ltd. This includes the new computerized lighting system.

Conversion of a Television Centre for Colour

Since LWT came into operation only in 1968, after the decision had been taken to authorize Independent Television colour, the company's engineers were asked early that year to prepare a master-plan for the technical development of this new company, with special emphasis on converting existing black-and-white installations for colour. It was necessary to take into account: the time scale; availability of equipment; available development effort; current and predicted production schedules, and the availability of areas and equipment for development; the ITA technical code of practice; budgetary cost and financial provision; operational philosophy and the foreseeable state of the technical art.

The master plan covered all necessary additions, and conversion to colour of the Wembley studios, based on the use of the company's own planning and installation engineers. It was necessary to take into account the need to train staff in colour operation. During the planning, it became clear that an optimum solution would come about from co-siting all active elements of signal processing equipment in one central technical area: this would keep the number of elements in any signal path to a minimum, obviating the need to equalize losses of long circuits; timing problems would be reduced; engineering skills could be concentrated in well-defined areas.

It was agreed that before any equipment was purchased the Company's method of use would be carefully defined. The engineers then produced functional specifications for each major type of equipment and compared this with published specifications of proprietary equipment: where significant differences were noted, manufacturers were asked to tender for delivery of equipment modified to meet LWT requirements.

Selection of equipment was based on suitability, delivery and price. The installation engineers had to meet the technical problem of acquiring and installing some £2-million worth of equipment to provide a fully operational colour television complex during the period of January to November 1969, while maintaining normal black-and-white service from studios already working to capacity; there was also need to provide a colour studio for training, and two further studios for programme stock-piling three months before the main target date.

Simple bar charts were found inadequate for project control and the engineers were trained in critical path analysis and project evaluation review techniques, and the application of these techniques resulted in a significant increase in efficiency. At one stage, there were some 2000 parallel activities, and a computer terminal with on-line and off-line access to a central London service was used for analysis and up-dating of network diagrams and CPA.

To maintain black-and-white production, a production and engineering control suite was created which could be connected to an overlaid ring main of camera and communication cables to operate any other studio on site, during the periods when the in-built equipment for that studio was being converted for colour.

The completed installation provides a fully colour converted system with four production studios and outside broadcast facilities, lines, network, presentation and full supporting areas and services.

Training for Colour

It was considered essential that all technical and production staff with significant involvement in colour operation should be trained with minimum disturbance to the continuing process of programme-making for black-and-white.

The company set up a colour training committee, with the necessary authority and financial resources to quantify and define the problems, and decide on specific means of meeting the needs.

Among the means adopted were the following: with the help of a local technical college and well-known technical personalities within the television industry, a series of lectures was prepared, covering theory and application of colour television techniques. This material was presented in a studio in front of tele-

Above: London Weekend's presentation suite

Below: The music studio control room at London Weekend showing channel controls on Neve mixer

vision cameras, allowing video tape recordings to be used for subsequent repeats. This enabled a large number of staff to be broken down into groups having the opportunity of hearing and seeing all lectures in either live or recorded form. By the end of April 1969, technical staff had received 33 hours of lecture material and were ready to embark on practical training in the first colour studio to be completed. The company has acknowledged that the success of its entry into colour was made possible only by the enthusiasm and zest of staff in facing up to the problem of preparing for colour operations.

Lighting System

This system basically uses a small memory which holds two lighting plots backed up by a large memory capable of holding 64 lighting plots. One complete lighting plot consists of the stored intensities of all 120 lamps.

In operation, plots which have been stored in the large memory are selected by numbered push-buttons; by pressing the appropriate button these are fed through one-at-a-time to the small memory. Plots contained in the small memory are handled separately as studio and mimic plots. Operations involving them are undertaken by means of illustrated controls grouped into Studio and Mimic operational panels. The Studio panel operates all lights in the studio, as shown by lamps on the display panel showing red. The Mimic panel does not normally operate any lamps in the studio, but is used for various operational functions, and the associated display is in white. In one respect (that of automatic cross-fades) it holds the incoming plot during the period of the cross-fade until such time as the outgoing plot is completely faded-out and the incoming faded-up in the studio. As soon as this happens the mimic plot in the mimic section of the small memory is transferred automatically to the studio section to control the lights. The original studio plot, now faded-out, becomes available for reference as a mimic display in white, having been automatically transferred to the mimic section of the small memory. This transfer takes place precisely at the termination of the longest part of a cross fade.

There is only one lamp selector panel combined with one brightness control panel for the control of individual lamps. For this reason, both are allocated for use with either of the studio or mimic panels, by pressing the combined-selector buttons situated on the individual lamp panel, and marked 'Studio' and 'Mimic' respectively.

To select lamps for control within the *studio* it is necessary to allocate the lamp selector/individual lamp control panels to operate with the studio panel. Then, any numbered lamp button which is selected will bring on the lamp within the studio at the brightness originally stored. If no brightness had been stored, brightness '1' will then be automatically stored. This will indicate merely that the circuit has been selected and will not bring up lamp brightness. After this, the brightness setting may be changed either by the pre-set brightness thumbwheel (the pre-set button has to be pressed for this), or by the normal operational brightness set-lever. This increases or reduces the brightness as the lever is moved.

The brightness changes are made more quickly if the lever is taken further from its centre rest position. The level of initially stored and subsequently set brightness of each selected lamp is indicated by a numeric display of brightness over a scale of 0 to 30 steps. If lamps are required to be switched off, or alternatively flashed for identification purposes, the on/off button may be used for this purpose.

By pressing the mimic allocation button on the individual lamp panel the lamp selector/individual lamp

Above: Control suite for all telecine machines

Below: Control suite for the special music studio at London Weekend

control panels work with the mimic panel only, and no lights are affected in the studio.

A special key may be used to insert into the write key switch which, when turned, enables recording of plots to proceed; otherwise only plot recall is possible.

In operational practice, the above procedures would continue until the desired lighting plot has been built up. The work may be stored in any one of the 64 numbered memories by initially selecting a suitable memory by number, and then pressing the red arrow button within the memory selector panel. In each case, the work will then be stored (this operation does not switch off the plot in the studio). The process of building plots and memories may continue as desired.

As a studio plot is being built up in the studio and being retained for rehearsal, other plots may be assembled by the mimic panel, using the brightness indicator only. It is then possible to store plots built up in this fashion by pressing the white arrow button within the memory selector panel.

By initially selecting the memory number and subsequently pressing either the red arrow button which transfers the stored plot into the studio panel, or the white arrow button which transfers it into the mimic panel, plots may be recalled for use.

Mimic plots may be added to an existing studio plot by pressing the '+' button, or deleted from the studio plot by pressing the '—' button. The augmenting action here which takes place involves the studio and the mimic plots only; plots are not augmented directly from the main store to the existing studio plot in this system. By pressing the 'sequence' (serrated arrow) button for either plot, the plot is recalled from the memory as selected and then the memory selector is advanced by one, at each operation.

To switch off a lighting plot, two buttons have been allocated on the memory selector, which are marked 'oo' or 'o'. Initially, pressing these buttons together switches off the plot in either studio or mimic panel when the appropriate input 'arrowed' button is pressed.

Plots recalled into studio and mimic panels may be cross-faded by pressing the 'up' and 'down' keys (providing 'manual' fade has not been selected). The cross fade continues at the present rate and as long as the keys are pressed. The progress of the fades is indicated by two meters; one for up-fade and one for down-fade. Normally the manual fade is left on, as on auto-fade the level tends to drift slowly over an extended period. During the auto-fade, when both fades have gone all the way, the controlling circuits reset, as already described, and the store and memory number indications change over.

By means of a modifier facility, a so-called 'modifier' plot is built up either within the studio panel or the mimic panel. This contains lamps with amended brightness, which are known to occur frequently within some of the stored plots. This modifier plot is held by a memory marked 'M' on the memory selector panel. By recalling the plot to be modified from M into the mimic panel, and then pressing the button marked 'M', this–and subsequent–plots recalled into the mimic panel are amended for brightness in respect of these chosen lamps. The modified plot may be returned to its original memory or transferred to the studio as required.

The 20 separate faders and switches are separate circuits quite unconnected with the normal control electronics. They may be introduced to control the separate dimmers by using the special dimmer control intercepting plug field provided. By inserting the plugs in each case, the fader may control the dimmer directly. This facility contains its own 10-v power supply.

Inserting the special key into the power-on key switch and turning, powers the system, provided that mains has been made available from the associated mains-breaker.

Inserting the special key into the clear keyswitch and turning enables the complete contents of all the memory to be cleared, by pressing the 'clear' button.

If the manual fade is switched on, the lamps from output and mimic displays are both turned in proportions set by the manual fader controls.

Two special keys are normally used as a security key panel. One switches on the power, as described, the other can be used in either the 'write' or 'clear' positions.

Equalizing Distribution Amplifier
An active video cable loss equalizer has been developed and designated EDA1-1. The basic module is 1·2 inches wide and a standard height of $3\frac{1}{2}$ inches of rack frame. The rack will hold up to 14 modules. Each module is self-powered and accepts one video input and provides one equalized video output: the insertion loss is 0 dB. Each module is capable of equalizing cable losses of up to 750 feet by adjustment of a simple variable resistor.

Sound Distribution Amplifier
Another of the series of units developed within London Weekend Television is a sound distribution amplifier for the distribution of audio frequency signals. This provides a high degree of isolation between outputs and an ample overload margin for operation use.

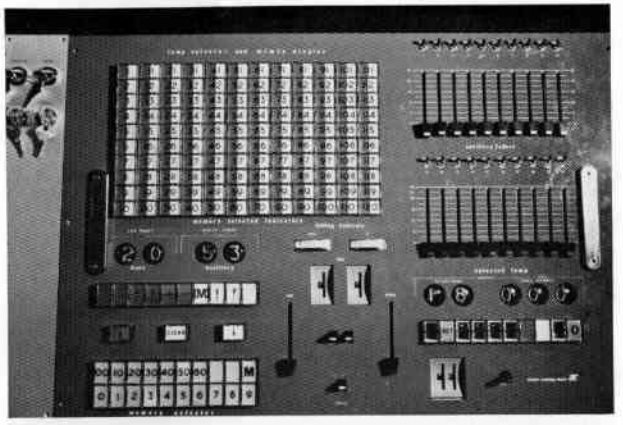
The input impedance (greater than 30 kilohms) allows bridging of sources without change in the signal level on the line. The unit is self-powered. Gain is unity to +20 dB (adjustable).

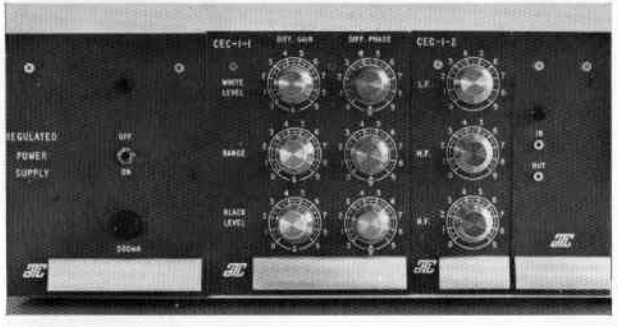
Top right: Control panel for the wire logic lighting system produced by Dynamic Technology in association with London Weekend. The system has flexibility in both intensity and pattern selection for all lighting plots. Meters are used to indicate rate of fades, for both up and down situations, and indicate the progress and cross fades when changing from a plot in the main memory to a fresh plot in the auxiliary memory

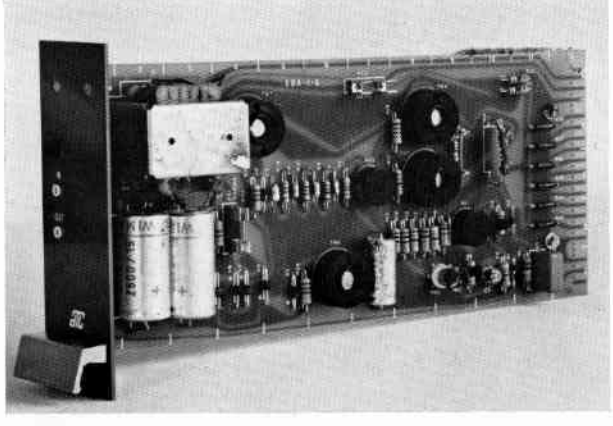
Centre right: The colour error corrector developed by London Weekend and now marketed through Dynamic Technology. This unit allows separate non-interactive adjustment of the low, medium and high frequency response of an in-coming signal and separate control of transfer characteristics. Differential gain and differential phase can be adjusted at white level and black level

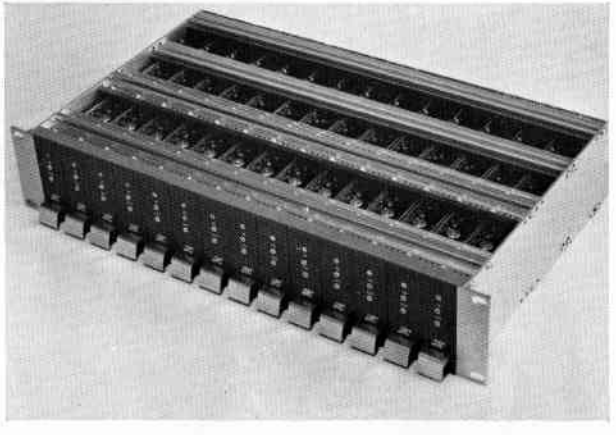
Bottom right: A rack housing 14 of the one-in, one-out equalizers

Below: A one-in, six-out equalizer amplifier designed to provide optimum performance at low cost. All known types of video cable can be equalized up to distances of 1,000 ft. Since the unit is self-powered, it can be accommodated in a centralized complex or at the working end of any cable









51 Technical Developments at Thames Television

This section describes briefly a number of technical developments and innovations which have proved of operational value in the studios of Thames Television at Teddington and Euston. Much of the development work has been carried out by the Engineering Department of the company, in some cases in co-operation with industry.

Remote Cue Delay Device

A remote cue delay device has been developed for use with VTR Editec. It will be appreciated that as the cue record and replay heads of an Editec-equipped VR2000 machine are physically displaced by a distance equivalent to 33 frames, remote cues are normally replayed 33 frames before the replay machine is required to start. The effect of this error is normally cancelled out by rewinding the machine 33 frames further back than the run-up time for which allowance has been made on the editing machine tape. The apparatus developed by Thames is used to delay the remote cue from the Editec VTR machine by 33 frames, thus removing the need to rewind by this extra amount.

For accurate editing, a switch is provided which gives the facility of varying the cue timing by 16 frames, in increments of 2 frames, on either side of the 33 frames; hence a delay of between 17 and 49 frames can be obtained. A number of other facilities are also incorporated.

Modifications to a Decoder

Modifications have been made to a commercially developed decoder in order to facilitate the monitoring of a colour genlock sequence. The provision of colour genlock monitoring allows the operator to observe when the station sync pulse generator is field, line and subcarrier locked, and correctly phased, to the incoming remote colour signal. The modifications involve driving the decoder with PAL switch, mixed syncs and subcarrier from the station sync pulse generator. The pulse signals from the generator are fed into the decoder via buffer amplifiers which provide loop facilities and also gain for the subcarrier and PAL switch signals. The amplifiers are mounted on a printed board on the chassis of the decoder. A relay allows the decoder to be driven from its internally generated pulses or from external pulses.

Telecine Afterglow Adjustment

The subjective assessment of afterglow on a picture monitor is made difficult because of retinal memory and simultaneous contrast adaption in the eye. Such effects are caused by the bright pictorial representation of the afterglow test pattern *after* it has done its job of testing the circuit. The principle is to pass the video being inspected through an electronic switch, timed to operate at the end of the test bars, in order to suppress the bright test signal, thereby leaving a very sensitive picture monitor display of *only* afterglow.

Photographing a Colour Kinescope

Special precautions need to be taken when photographing a television picture in order to avoid interference between the moving camera shutter and the television scan. An electronic timing unit has been developed that switches the television picture on when the shutter is fully open, after receiving a trigger pulse from the camera's flash contact. It should equally be possible to apply these principles to a domestic television receiver having an input for a flash contact and a switch marked 'TV' or 'Photo'. It has been found in practice that a normal colour monitor greyscale balance (6500° K) produced first-class results on Agfa CT18 film, setting highlight brightness to 25 ft-L at $f4$ for one complete frame.

The original application of this equipment was to photograph the television coverage of the Apollo 11 moon landing; the more conventional approach–to increase exposure time–was not acceptable since it was wished to freeze motion at least as well as the television camera had done. An electronic solution is to pulse two television fields on to a picture monitor, when the camera shutter is open; this may be synchronized to occur at precisely the right moment by triggering the electronic shutter from the camera's flash contact. An electronic delay is started and adjusted to wait until the shutter is fully open; it then initiates the selection of the next two fields. After the television exposure the camera shutter may close. The motion-capturing ability of such a system is determined by the television pick-up tube being used and the television repetition rate.

'Cinetronic' Automatic Film Presentation Equipment

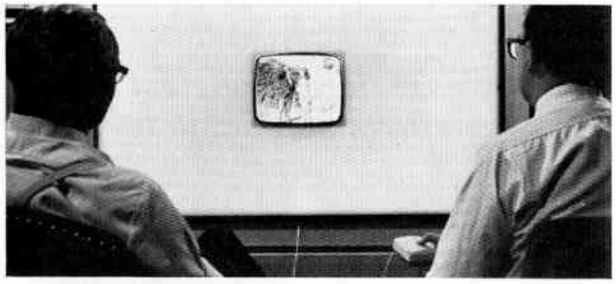
While the primary purpose of an investigation into the problems which would arise in introducing a comprehensive system of automation into a cinema was not initially directed towards television, many of the techniques are considered to have direct application to the operation of television facilities. In the process of the investigation, equipment was developed to automate many of the operations currently performed manually in most projection rooms. The systems are based on the premise that the film acts as a medium for the storage of data required for the automation process. Thus the data is presented to the system in a correctly timed sequence, taking fully into account the variation in projector running times.

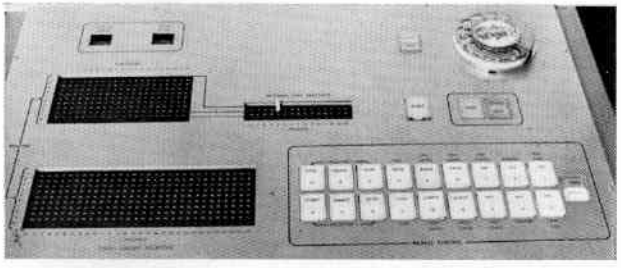
In the Mark I equipment it was decided to use a single sequential code and to have the capability of detecting up to ten pulses. This choice enabled experience to be gained with cue detection and processing before passing on to more complicated systems.

Cues are detected from the film by reflected light pick-up and the pulses so derived are passed into a counting device which senses the number of pulses received and gives an output related to this number, and hence related to the required routine. The selected routine information is then fed to a processing unit where the functions of that particular routine are initiated on a time scale governed by a built-in clock.

The original equipment was installed in one of the review theatres at the Teddington Studios. It controlled a Philips FP20 projector, house lights, footlights, spotlights, curtains, synchronous and non-synchronous sound. A cassette tape machine provided the non-synchronous sound while an automatic fade amplifier was designed to operate from logic signals supplied from the control equipment.

A Mark II equiqment has the film coded in a different way: two identical sequential codes are staggered one behind the other down one side of the film to overcome the problem of stray pulse pickup. The functions controlled by this equipment include house lights, presentation lights, tabs, masking, non-synchronous sound, and two projectors, but the equipment has been designed in a modular form to allow other functions to be added. The equipment is completely digital and is constructed on some 50 logic cards, with integrated circuits providing some 90 per cent of the electronics. This equipment was described at 'Film 69'.





Above: Colour film assessor–back projection version

Centre: Cinema automation control panel

Below: Colour Genlock decoder–RBM decoder modified

Optical Simulation of the Televising of Colour Film

Television equipment causes film to appear differently when it is televised and viewed on a colour television receiver than when it is optically projected in a theatre. Typical television viewing is more critical of some aspects of the film quality, although less critical of certain other parameters. Ideally, colour film intended for television should be reviewed on colour television equipment; however the capital cost of such equipment is high, and if it is to be kept in a consistent state of line-up, truly representative of broadcasting, then the operating labour costs are also high. There is also the problem of defining what is to be regarded as a standard telecine. There is much to be said in favour of optical projection if the appearance of the film image can be visually modified to produce effects similar to the distortions introduced by the television chain.

Thames has had experience with four types of simulator since experiments were begun in this area in February 1967.

(1) Back projection on to a CRT faceplate surrounded by a small bright adaption field.

(2) Similar to (1) but with a large surround held at $\frac{1}{3}$ peak white, with provision for it to be switched to peak white. One effect of switching the surround to peak white is to up-gamma the perceived picture, and this is of use in checking whether the film is too contrasty to televise well. This is of paramount importance with night scenes, and the like.

(3) As (2) but using front projection in a review theatre decorated with off-white walls and diffused ambient lighting.

(4) Direct projection with the adaption surround formed by placing fluorescent lamps on the back of the

screen and allowing them to illuminate a white wall behind.

The screen may be a standard television colour tube faceplate that has been sprayed with a suitable screen material to remove the directional transmission characteristics ('hot' spot) from the projected image. This screen is mounted in an adaption-surround which is illuminated by fluorescent tubes with a colour temperature of 5400°K. While a film is being projected this surround is held at a luminance equal to half peak white so as to keep the viewer's eyes adapted to a constant white point. This surround should fill the whole field of 190° that the eyes can resolve, but since this is impracticable, the rest of the viewing theatre is illuminated in two ways. First, the field of view behind the simulator is filled by grey curtains which are illuminated to a luminance of approximately 0·25 the peak white of the picture. Secondly, the rest of the theatre is furnished by curtains, chair coverings, and the like to integrate out to a neutral and the back of the viewing room is dark to eliminate reflections from the screen faceplate.

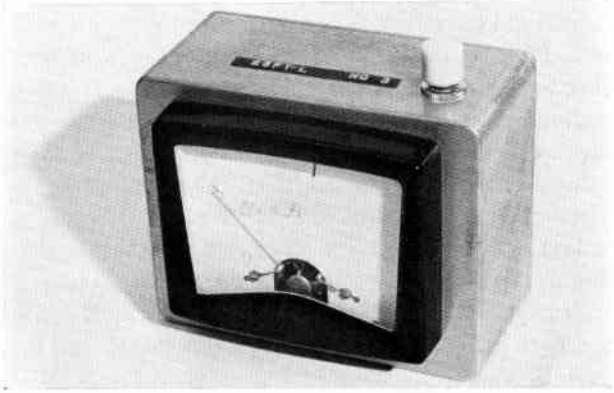
Attention is drawn to the ITCA Technical Report No 26, 'Viewing conditions in review theatres' in the ITCA series on Technical Standards and Transmission Requirements.

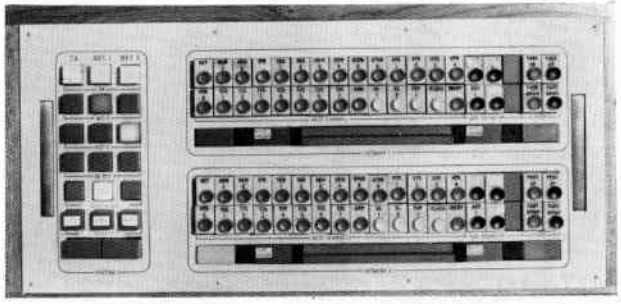
Computer-aided Programme Presentation

The building of a new studio centre in London for the production of topical news programmes and the on-air operation of Presentation and Master Control provided Thames with the opportunity to use a form of computer control in these operations.

At any time before the day of transmission, the programme schedule is typed out on a Teletype machine and each item is verified by the computer before it is punched on to paper tape. Information entered concerns the time of starting, duration, originating source, programme title and number, and whether the programme is for local or network transmission. Once the tape has been produced it is kept until the day of transmission when it is fed into the system. The information is again verified and the appropriate 'roll' cues for telecine and VTR machines are generated; i.e. a six-second cue for telecine and a 15-second one for VTR. The status of VTR and telecine machines is continually checked, and when a reel of programme material is loaded on to a machine its identity badge is inserted into the badge reader. The system then reads the badge and searches the programme schedule for the corresponding number. Once this is located, the machine number is inserted into the appropriate place on the data displays. If the machines are not loaded five minutes before transmission time, the corresponding line of information starts to flash once every second until the machine is loaded. This flashing will commence again if the machine is not placed in the remote starting mode three minutes before 'roll' time. Any change of status in the machine will immediately be displayed to the transmission controller, who is the executive officer in charge of presentation. If the machines start to run and then, for any reason, stop, the programme automatically selects a stand-by slide.

The computer has a 12-bit word length, 8K of core storage and 32K of disc storage. Mounted on-line to the computer are two Teletype machines, one for basic computer operation, and one for data entry and programme output logging. In the Master and Presentation Control areas are two 1000-character data displays with keyboard entry; one displays the switching operations applicable to the Network output, and the other displays the operations applicable to the Presentation output.





Above: Colour monitor set-up light meter

Centre: Computer-controlled Network switcher panel

Below: Computer-controlled switching-readout of schedule

Colour Monitor Set-up
A compact and economical peak white brightness meter has been developed as part of a programme to standardize operating conditions in Thames, with a view to reducing environments that encourage picture miss-match. The instrument consists of a rectangular photo cell measuring 37 mm by 50 mm, mounted in a diecast box with a fully screened 50 μA Taylor meter and a push-button on/off switch. The photocell response is corrected with a green filter to give the instrument approximately photopic response. The scale has a thin zero mark and a bold mark at 30 μA, and each instrument is adjusted (AOT fixed resistor) for 30 μA from a 19-in colour picture monitor of 25 ft-L brightness, the latter calibrated with a Pentax spot meter.

Illuminant D Cathode-ray-tube Phosphor
Until recently it was not possible for television contractors to obtain monochrome cathode-ray tubes with an illuminant D phosphor, for control room use, that would match the colour tubes white point. Early in 1969, Ferranti were asked to investigate the possibility of producing such tubes for the data displays to be installed in the Euston Master and Presentation areas. The manufacturers are now able to offer a phosphor that visually matches Illuminant D, at a small additional cost, and are investigating the use of this phosphor in more commonly used cathode-ray tubes.

Vision Identification Generator
ATV Network have devised an audio-tone-operated indicator to show the source of programmes during line-up, and an equivalent indication is desirable for the picture. In this connection Thames Television have produced an all-electronic character generator which produces the word 'THAMES' at a spacing suitable for inserting over colour bars or other signals.

Most character-generators must produce the complete alphabet and figures, so that the shapes of the characters are usually a compromise between legibility and the reduction of circuit complications. In the word THAMES, it is possible to make all the letters from rectangular elements by 'squaring' the A, M and S without sacrifice of legibility.

It has, therefore, been possible to simplify the waveform generator and produce a unit at less cost and complexity than a universal character generator.

Standardized Digital Coding System
It has become increasingly apparent during recent years that digital techniques are likely to be widely used by the television industry, and that the trend will spread also to the film industry. Thames Television decided some time ago, that, unless standardization was achieved at the outset, a likely result would be the chaotic conditions that pervade the computer industry with respect to compatibility. The company has proposed, therefore, a standard digital code structure that should be comprehensive enough to keep pace with the fast-moving developments in these industries concerned. By adopting a standard code and placing coded information along the film edge, on video-tape, on paper tape, or in a magnetic store, a number of necessary–if tedious–operating functions can be mechanized; e.g. fast search and retrieval for editing, colour-balance correction during transmissions and the like, all become possible.

To aid identification of the various sections of the code it was decided to split the information into several blocks on the recording medium. The first block could be positional information, the second block could be for identification and various control purposes, and the third block could be used for synchronizing and machine control purposes. It was also decided that the information should be recorded in binary coded decimal form.

The proposed code, which will be more fully described in a paper written for the *BKSTS Journal*, is the result of the views of many people in the film and television organizations, in industry, and also investigation into other coding systems. It is considered that, unless a standardized code is agreed very soon, at least in the United Kingdom, compatibility will never be possible: the result of this would be that large sums of money will have to be spent on compromise equipment designs.

BKSTS Reference Leader Picture
Members of the Engineering Research Group of Thames Television have described the technical reasons behind the picture-design adopted for the BKSTS reference leader picture, intended to assist the objective and subjective colour balance control of 16 mm and 35 mm prints in both the film laboratory and the television studio. Four frames of the standard negative are inserted in the leader at the colour reference position of each cut negative roll, and the whole roll is then graded to look consistent with the leader picture. The leader picture later helps the telecine operator to adjust the colour balance of his machine. The original test scene was constructed of specified materials and special care was taken to ensure that the 16 mm version has a grey area big enough for easy routine densitometry. Both 16 mm and 35 mm negatives are available as the BKSTS Girl No 1 (5254) and BKSTS Girl No 2 (7254), and prints are available graded to Status A neutrality on the Control Square. The basic aim of this project is to encourage a common method of colour balance control through the use of a standard negative .

Colour Monitor Comparator
As a result of close co-operation between the Engineering Research Group of Thames Television and Grafikon (Engineers) Ltd, a colour monitor calibrator has been designed to meet the requirements of the television industry. This calibrator is a hand

held optical instrument that enables the white point of a colour monitor to be visually set to the UK recommendation of D(6500). The instrument is offered up to the face of the monitor and the monitor controls are then adjusted to make the colour picture match the reference colour of the instrument. The comparison between the monitor and the reference is seen in a Lummer Brodhun photometer cube. The reference colour is obtained from a tungsten halogen lamp and glass filter and is diffused to form a very even reference field.

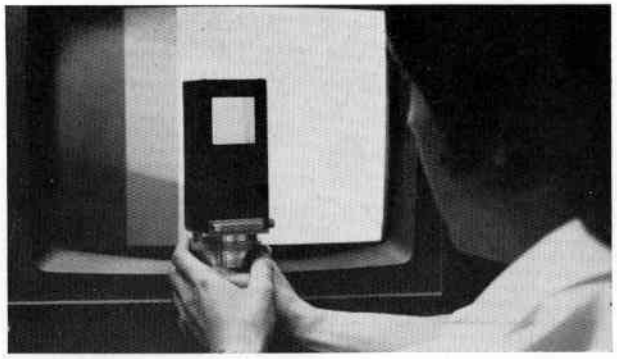
Camera Spectral Response Test

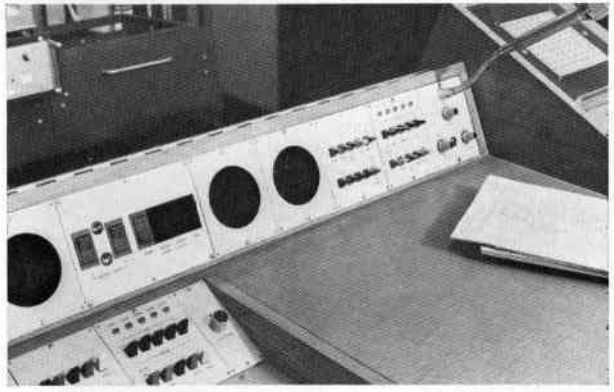
A method has been developed for recording a camera's spectral response on Polaroid film, in order to detect spectral differences within a batch of cameras that could otherwise cause picture mismatch amongst them. The method is to illuminate evenly a Veryl spectrum wedge filter with a tungsten lamp, and then to photograph the resulting waveforms from a waveform monitor.

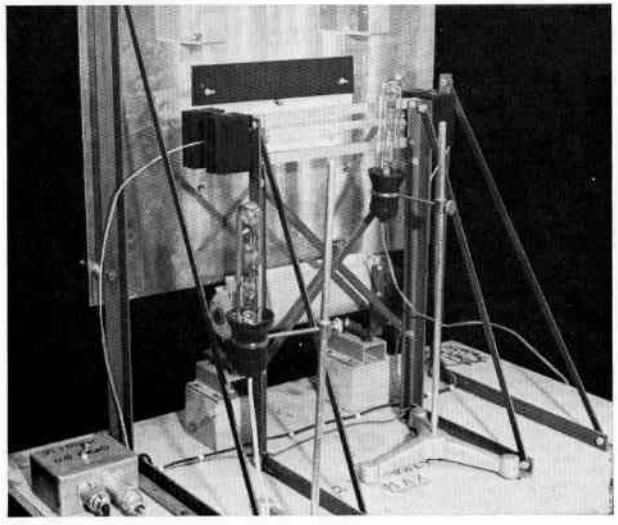
A considerable problem was encountered in getting even filter illumination. A solution was sought by using a lamp longer than the filter. A 1 kW, 20-cm long, tungsten halogen lamp was used, together with a tangential blower to cool the lamp and filter.

Special precautions are taken to ensure that each camera has its optical axis aligned normal to the filter.

Wavelength calibration was achieved by adjusting the X gain on observing the spectral lines from a sodium and mercury gas discharge lamp through the Veryl filter.







Above: Optical Colour Temperature Calibrator (now marketed by Grafikon)

Centre: Inter-area communications units on a vision/lighting control desk

Below: Camera spectral response movement–view from behind fitter showing light source

Digital Servo System for the Synchronization of Non-sprocketed Tape Records

This system is being described fully at IBC70. It has been designed to overcome a number of defects encountered when using currently available equipment by using helical scan VTR machines wherever possible, by using multi-track audio recorders to provide greater operational flexibility and by providing a synchronizing system to allow any of the three types of recorder (that is quadruplex VTR, helical scan VTR, and multi-track audio recorder) to be locked to any other. The original programme sound is copied on to one track of the multi-track audio recorder and the vision on to a helical scan machine. These are operated in synchronism whilst the new sound track is prepared using multi-track techniques. To eliminate 'wow' problems the helical scan VTR is used as the controlled element in the synchronizing system. The new sound track is transferred from the audio tape back to the quadruplex VTR by use of the same synchronizing system, using the VTR as the controlled element to eliminate the power amplifier which would be needed to drive the audio machine.

The synchronizing system records, using normal bias, a numerical code on the cue track of the quadruplex VTR, the sound track of the helical scan VTR and one track of the multi-track audio recorder, whilst copying the edited programme material. The present code is a ten-bit, bipolar return-to-zero code counting television fields in pure binary. A space is left between each group of ten bits for synchronizing the decoding circuits. The ten-bit code repeats at roughly 20-second intervals, implying that the synchronizing system can tolerate an error of a tape length equivalent to ± 10 seconds. The system was designed with this fairly limited range to enable the code to lie entirely within audio band limits. The company is investigating, as mentioned elsewhere, a standard digital code to be used both for VTR editing and for the location, process control and automated editing of film sequences.

Colour Camera Test Chart

A prototype reflectance test chart (designated TC10) has been developed to aid the line-up of EMI 2001 camera channels. Advantage has been taken of the absence of linearity controls in this camera in order to arrive at a very simple registration pattern. It follows that conventional registration patterns may be more suitable for other types of colour cameras.

The TC10 chart provides elements to help carry out the following adjustments: focus alignment, registration, grey-scale tracking and flare correction. By combining all these in one chart the operational problems of a studio camera line-up are greatly reduced. A special test chart holder was designed because the TC10 has a large box at the rear of the black hole, preventing the use of conventional caption stands. A full description of this chart is given in 'Preparations for Colour Television' published in the January 1969 issue of the *BKSTS Journal*.

Vertical Aperture Correction with Flying-spot Apparatus

In a typical path of televised film pictures losses in edge contrast can occur at each stage owing to aperture distortion. This degradation is incurred when the effective aperture size is significant relative to the picture element to be recorded or replayed. The overall loss of edge contrast on picture information which has passed through such a chain is considerable; a total loss of detail information relative to low frequency modulation on 16 mm material can be as high as 15 dB. These losses can be approximately made good when one overall correction is applied to the output signals of flying spot telecine apparatus.

Various methods of applying vertical aperture correction to tri-stimulus origination equipment are possible. Advantage is usually taken of the eye's low resolving power to sharp colour changes and the correction is usually applied only to the luminance component of the picture. A system used for three tube cameras ('contours out of green') derives the correction signal from the green signal only, so that saturated red and blue signals are not corrected. The system currently employed by Thames Television makes use of gamma corrected RGB signals from telecine to form a separate luminance signal. This signal is then passed to an electronic camera-type aperture corrector unit; the output from this unit is reblanked and applied to the coder luminance input. The amount of aperture correction that can be successfully applied is limited by telecine noise performance and film grain size.

The output signal from the aperture corrector is delayed from the input by an amount of one television line, due to the vertical correction circuits plus 400 nSec due to the horizontal correction circuits. The short horizontal timing error has been successfully removed by shortening the luminance delay period incorporated in PAL coding equipment. The remaining one-line luminance delay is seen on PAL delay line receivers as only a reversal of the colour picture vertical shift from a downward direction to an upward direction.

This form of correction is particularly useful on 16 mm insert material and picture sharpness of this material is now approaching that obtained from electronic cameras. Considerable improvements in picture sharpness have also been observed on 35 mm film commercials, which often have additional aperture distortion due to the application of optical effects. The advantages of these corrections are seen equally on black-and-white as well as colour receivers. The vertical enhancement is fully preserved even on receiving equipment with restricted bandwidth.

Telecine Grey Correction

Grey scales on colour film are not televised correctly by current telecine equipment. This is shown by the spectral transmission of (a) flying-spot telecine equipment, and (b) a typical colour film neutral which has a nominal transmittance of 10 per cent. Unlike ideal neutral density filters, which would have uniform spectral transmittance, the colour film neutral contains troughs in its spectral transmittance characteristics at the red, green and blue regions of the spectrum. The trough in film transmittance due to the magenta dye *coincides* with the spectral peak in the green light transmitted by the telecine. Further, the red and blue lights from the telecine have their spectral peaks in regions just offset from the red and blue troughs in the film transmittance. The green light thus suffers more attenuation than does the red and blue. The green signal is consequently smaller than the red and blue, and the film is wrongly reproduced with a magenta hue.

Since this error is directly proportional to the amount of dye carried by the film, a logarithmic form of correction is required. In typical equipment, the gamma correction power law is proportional to the amplitude of signals by adjustment to the resistor values which determine the blue component in the yellow masks. Similarly, the red gamma characteristics may be varied by adjustment to the resistor which determine the amplitudes of the red component in the cyan masks. The modification was fitted to a machine at the Euston centre in December 1969, incorporating a manual switch which is operated in the interval between monochrome and colour commercials. Machines incorporating grey correction have been found to have less need for TARIF correction.

Distributing Television Pulses in Coded Form
The adoption of the PAL system for the British colour television services has made necessary the use of seven sets of synchronizing information for studio centre use. As more than one source of these sets of information is normally available on a studio site, problems of pulse assignment as well as of pulse distribution and timing arise. It was to simplify these problems that an attempt was made to combine all or some of the seven individual sets of information, thereby reducing the number of assignment and distribution channels required. At the outset of the project it was decided that no attempt should be made to combine the colour subcarrier with any other signal, as it is necessary that no phase or amplitude modulation of the subcarrier should occur. The remaining six signals have been combined to form a signal for assignment, timing and distribution.

Inter-area Communication Units
A modular system of inter-area communication units have been designed to overcome the problems experienced with commercial 'office intercommunication units'. There are three basic elements:

1 A loudspeaker in an enclosure designed to improve speech intelligibility.

2 An amplifier unit, having a microphone mounting, microphone-to-line amplifier and two line-to-loudspeaker amplifiers, gain controls and provision for mixing other inputs are provided.

3 A key unit for selecting the called station, up to twenty stations from each box but two or more boxes can be linked together.

The units are all $5\frac{1}{4}$ in. high, $4\frac{1}{4}$ in. wide and approximately 8-in. deep, suitable for mounting in a 19-in. rack, in groups of four, or in control desks. A multi-pair cable connects units, each station having a 'ring' connected to the loudspeaker amplifier to which other stations can switch their microphone amplifier output. A station cannot, therefore, be 'engaged' and so fail to receive a call. A muting relay is incorporated to reduce the loudspeaker level while speaking oneself–this is a precaution against howl-round if two stations speak simultaneously to one another.

Good quality, moving-coil microphones have been used to assist clarity of speech; about 1-watt output is available from the loudspeaker amplifier, and this has proved adequate for telecine and VTR areas. Speech quality is such that, in practice, individual voices are recognized, even when omitting to announce identity. The loudspeaker enclosure is a heavy wooden box in conjunction with an economical 3-in. speaker, giving a response which falls off below 250 Hz and above 4 kHz. The entire system operates from 24-volt DC supply and can be left running, while the rest of the station is disconnected from the mains supply–a useful feature during installation and maintenance work.

DC-controlled Sine-wave Oscillator
This unit, which is a modified form of a zero phase shift oscillator, makes use of a variable control element believed to be of original design, and provides a sine-wave output whose frequency may be varied at exponential rate with applied linear DC voltage. The oscillator frequency may be remotely controlled and remotely monitored on a meter.

The unit may be operated in a manual, sweep or step mode. In the case of the step mode, provision is made for 3, 7 or 15 frequency bursts, mute, ident, and inhibit facilities are also made available.

The sweep and step periods are variable up to a maximum of 45 seconds and the frequency range has been set up to a range of 2000:1 (10 Hz to 20 kHz).

There are two outputs: 600-ohms balanced at zero level maximum, and unbalanced at 1000-ohms impedance + 10 dBV maximum.

Fibre-optic Pipe for Light Source Comparison
The principle of the spot photometer is well known in its application to the comparison of light values and colour hues. This device is a variation of this basic technique.

A co-axial matching field is provided on the combined face of a two-legged fibre-optic pipe. One branch is taken to a light of reference brightness and/or colour, while the other views the stimulus to be standardized. The discrepancies between the two light sources can be viewed in the concentric window. When both limbs are placed on the same source no viewable difference can be detected. The device has the advantage that the limbs are flexible, enabling both light sources to be placed in convenient positions.

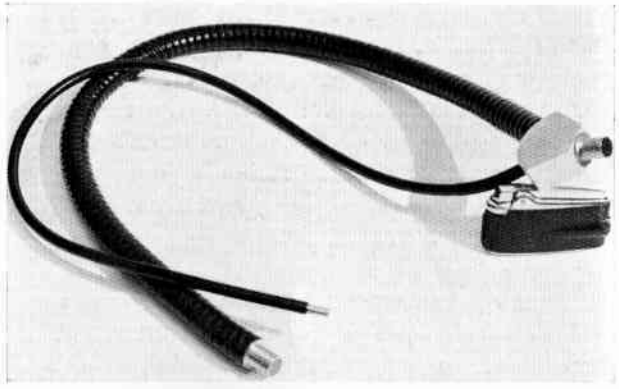
This device is now available through Rank Precision Industries Ltd.

Free-Grouping Sound Console
In the preparations for the changeover to colour operation, it was decided to renew the Thames sound consoles and associated units, and to attempt to rationalize the whole concept of television studio sound control. Far greater flexibility is required of the sound control arrangements than those for vision, since the number of microphones and high-level sources bears no relation to the number of cameras or size of the studio.

The new range of equipment is all on castors, so that units can be moved between studio suites as required for programme or maintenance. All units, even the 24-channel consoles, are on plug-and-socket arrangements, and, so far as possible, are all modular sizes.

The sound consoles were made by Rupert Neve Ltd to Thames designs, and use a system of 'free grouping'. All channels are gain-controlled in 5 dB steps by means of one switch, between −80 dB and +10 dB. Channel modules are thus suitable for microphone or high-level inputs and include equalization. The basic desk has 24 channels, but one or two 12-channel units can be added to it. Each desk has four mixing 'bus-bars' or 'groups' to which each channel can be switched; the outputs of these groups can, in turn, be pathed to any channel which becomes the group fader. Thus, the operator has complete freedom to plan the configuration of the console to suit the particular show concerned.

The high-level sources–tape, cassette and disc–are taken to a six-channel, two-group sub-mixer. The cassette unit, containing sound effects, loops or a telephone 'distort' network, can be cued directly by the vision mixer to avoid the problem of keeping picture and sound cuts in step. Pre-set 'clean feeds' of any channel can be selected by the channel-switching unit for 'foldback' of sound effects or high-level sources to the artists in the studio. Audience public address or echo feeds are selected in a similar manner. Each channel has a switching unit and an amplifier/equalizer unit. Insertion points are provided for compressors, and the like, on a new jackfield. The auxiliary facilities include camera switching, re-routing operated by a footswitch, talkback with footswitch, remote control or two echo machines, on-air/rehearsal light switching, talkback microphone, two compressors (plus one on each 12-channel extension unit) and Perspex adjustable script-board on a cantilever arm to avoid the necessity for a fixed script-board in front of the faders.



Left: Fibre-optic pipe for light source comparison

Below: Free-grouping sound console made by Rupert Neve Ltd to Thames Television designs. All channels are gain-controlled in five dB steps by one switch between −80 dB and +10 dB

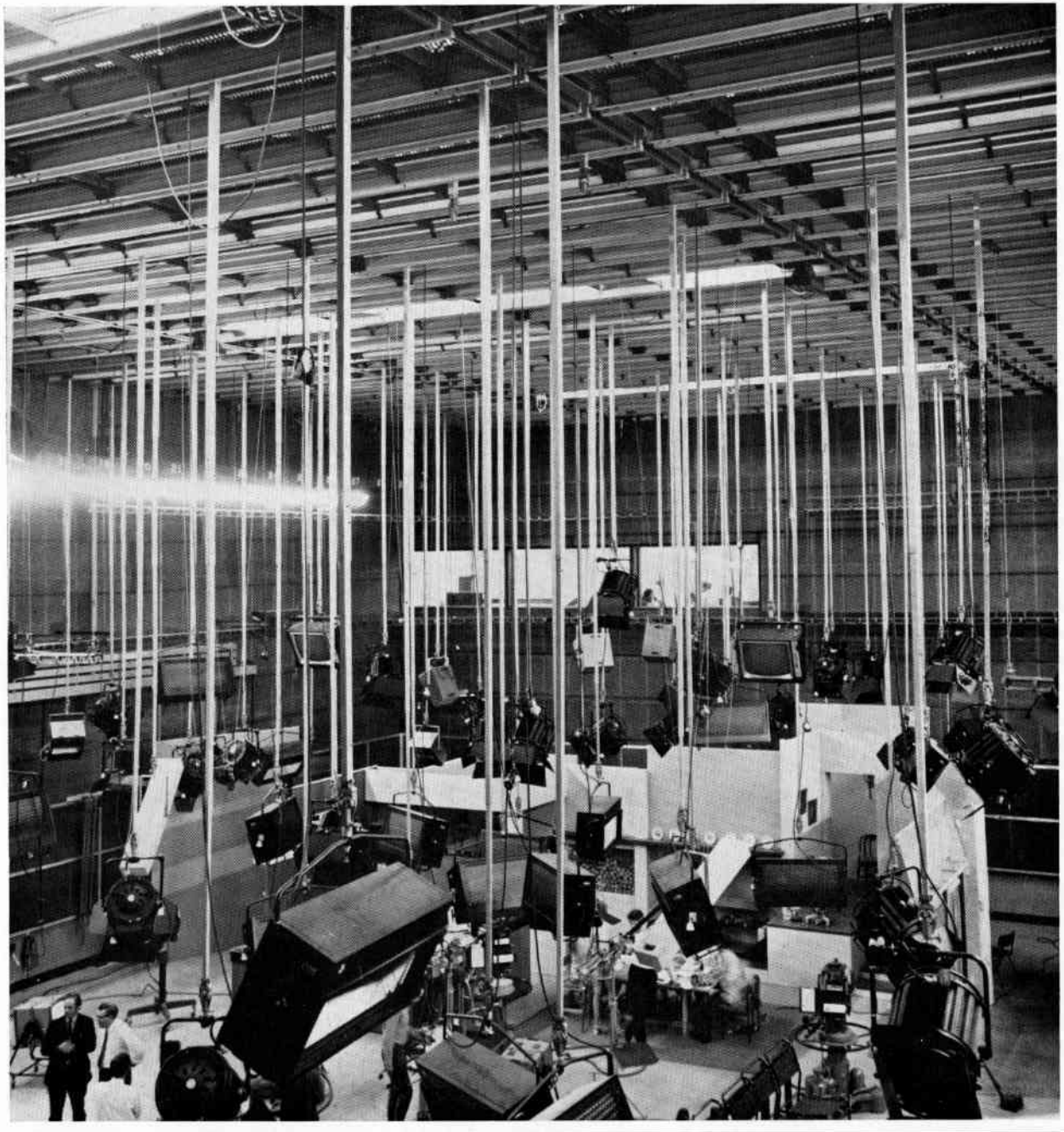
59 Southern Television's New Studio Centre

SOUTHERN
INDEPENDENT TELEVISION

Southern Television's new £2½-million Studio Centre, equipped for full colour operation, has been completed. The Centre is built on land reclaimed from the River Itchen at Southampton and comprises two main blocks in which are housed the production facilities and the administrative offices. The Centre has four studios: Studio 1 6000 ft², Studio 2 3000 ft², Studio 3 1200 ft², Studio 4 350 ft². A full description of the Centre appears in *The Royal Television Society Journal* (July/August, 1970).

The total electric load for the Studio Centre is 1·7 MW and this is supplied by two 6·6 kV feeders from the local Electricity Board. Two 1 MW transformers in the Centre's substation reduce the voltage to 240v for distribution to all areas. All electric power used by the electronic equipment is routed via voltage stabilizers to minimize the effect of incoming mains variations, and to guard against complete failure of the public electricity supply a 30 kVA diesel alternator has been installed to provide power to maintain essential equipment to operate a broadcast service.

The lighting system in Studios 1 and 2 utilizes a Mole-Richardson slotted grid. 150 lighting telescopes are available in Studio 1 and 75 in Studio 2. With their transfer slots, the grids and telescopes provide mobility to position the luminaires (lamps) anywhere in the active studio space. The system allows scenery and lamp setting to take place simultaneously. Microphones and audience sound reinforcement loudspeakers and monitors may be slung from the grid without impeding the movement of the luminaires and provision is also made to suspend light scenery.



Studio 1–showing the lighting grid–at Southern Television's new studios

There are two basic types in use–a 5 kW $2\frac{1}{2}/2\frac{1}{2}$ double filament fresnel luminaire and a 5 kW soft light, both fully pole operated.

The three production studios have the latest type of Thorn computer lighting control systems permitting the memorizing of 100 complete lighting plots, together with their dimmer settings. Studio 1 has twenty 10 kW and one hundred and sixty 5 kW dimmers installed, while Studio 2 has eight 10 kW and seventy-two 5 kW dimmers and Studio 3 has forty 5 kW dimmers. The control system for Studios 2 and 3, supplied by Thorn Lighting Limited, was the first to use their Duplex method of operation where a common store and control system is used to operate the dimmers of the two studios simultaneously.

Studio Control Rooms

The control suites for Studios 1 and 2 are raised 16 ft above the studio floor and give a commanding view of the artistes, cameras and sets. They are positioned across the ends of the studios and are divided into sound, production and vision/lighting control rooms. Studio 3, which is used mainly for news and documentaries, has its control suite at studio floor level and is divided into production, vision/lighting and a separate sound control room. All vision and sound control for Studio 2 is for the moment being provided by the Outside Broadcast Unit. A full-size studio control room has been constructed to service the studio but is currently equipped only with lighting control facilities.

To meet the demands of the widely varying types of productions mounted in the studios, a high degree of flexibility has been built into the sound control desks. These have a complement of 24 channels in Studio 1, supplemented by a further 12-channel desk normally installed in the Sound Transcription Room. A 12-channel desk is available in Studio 3. In addition to the normal disc and reel-to-reel tape machine facilities, extensive use is made of cassette tape machines in these new control rooms.

Studios 1 and 3 production control rooms are fitted with a vision mixer of the A/B–C/D type and each is provided with special effects equipment. In addition to providing the normal 'wipe' facilities, this enables the inlaying of all captions and permits production techniques such as chroma-key to be used. All picture sources in the Centre are available to vision mixer inputs, with local selection on the production desk. Stop, start and rewind functions of telecine and video tape machines together with slide and caption change controls are available to control room personnel. The production control rooms are equipped with a monochrome picture monitor for each camera output, and each remote source input, plus two switchable preview monitors and a colour transmission monitor.

The studios are equipped with Marconi Mk VII colour cameras. Four of these are available in Studio 1, and three in Studio 3. Studio 2 is served by the Outside Broadcast Unit's four cameras. The Presentation Studio also has a colour channel and another is held in reserve. All cameras mount Rank Taylor Hobson zoom lenses.

Central Area

Within the central area are housed presentation and master control rooms, telecine and video tape areas, a sound dubbing suite, the central apparatus room and electronic maintenance. The central area is on the ground floor, with mechanical maintenance workshops and technical stores immediately adjacent.

Most of the Centre's electronic equipment is housed in 50 equipment racks in the Central Apparatus Room, including the electronics of all studio camera channels. This centralization of equipment in one area minimizes the length of cables interconnecting the various items of equipment, reducing considerably the timing and equalizing of video signals–a task which is much more exacting for colour than for monochrome. Two operational pulse generators are installed, one normally for Presentation and the second for Studios. Both pulse generators are equipped with colour genlock enabling studios as well as Presentation to handle external sources, such as incoming network signals and outside broadcasts. On occasions when the Outside Broadcast Unit is servicing Studio 2, the Unit's Sync Pulse Generator will also be available. Pulses for telecine and video tape machines, caption and slide scanners are automatically switched between the three systems depending on whether they are working into studios, the OB Unit, or Presentation Control. The entire system has been designed and manufactured by the Marconi Company.

The presentation switcher, specially designed by the Marconi Company, provides cutting and mixing facilities between its 24 sound and vision inputs. Special effects equipment is also included to permit inlay of captions on the transmitted picture. In the Presentation operation, difficulty has often been experienced due to the large number of sources which have to be selected and sent to transmission over a relatively short period. During a commercial break ten or more source changes may well take place in two minutes, and this is further aggravated by Southern Television's frequent requirement to feed the transmitters on the Isle of Wight and at Dover with different signals. To minimize operational error, equipment has been provided to memorize these source changes prior to programme breaks and up to 16 event changes can be stored on the presentation output to the ITA Isle of Wight transmitters and eight events on the ITA Dover transmitter feed.

The master control room is immediately adjacent to the presentation control room. Its comprehensive sound and vision monitoring switch systems, built by Marconi, have been designed so that they can be

used for presentation switching in the event of failure of this equipment–thereby ensuring continuity of service to the viewer.

Telecine

The Telecine area is equipped with four Uniplex 35 mm colour machines, four Uniplex 16 mm colour machines and two dual colour slide scanners. All these machines are of the flying spot type manufactured by Rank Cintel. Additionally, two vidicon caption scanners will be available. Two 16 mm magnetic sound reproducers installed in the film dubbing suite may be interlocked with two of the 16 mm telecine machines. A central control desk is installed in the telecine area permitting an operator to control all operational functions of machines, or alternatively to assign their control to studio or presentation control rooms. The assignment switcher involves the switching of talk-back, monitoring, pulse, sound, vision and cue circuits, in addition to motor control information.

Three VR2000 colour video tape machines are installed. One is equipped with an Editec computerized electronic editor to speed up the editing process and provide programme directors with more precise editing facilities. Operators can select all vision and sound sources in the centre for recording purposes and, when replaying, may assign control of their machines to studio and presentation control rooms via the Marconi assignment switcher. Control of the assembly editing machine functions can also be assigned to any studio.

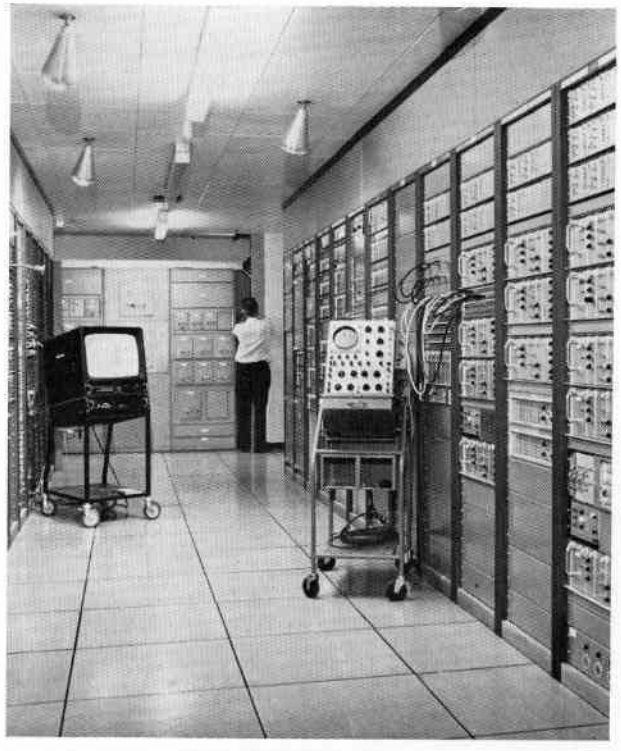
Film Department

This department, which is one of the most compactly designed in the world, is equipped with one PAKO 16 mm colour processor, plus one Lawley 16 mm black-and-white processor. The maximum colour film output is 2400 ft an hour. The black-and-white output is 2800 ft an hour. The film stock used is manufactured by Agfa Gevaert.

The department is equipped with seven cutting rooms, and, in addition to a dubbing theatre, has two preview theatres–one for 35 mm and one for 16 mm.

The dubbing theatre utilizes the 'rock and roll' system which enables the dubbing mixer to roll back for up to thirty seconds should any mistake be made, and precludes the necessity for the entire film to be unlaced from the machine and re-wound by hand.

Throughout the planning of this studio complex, considerable care has been exercised to use, as far as possible, British-made equipment.



Left: Part of the Central Technical Area at Southern Television's new studio complex at Southampton. In the foreground are Video-tape Machines. Behind is the Telecine Control Desk

Right: The main equipment racks in the Central Apparatus Room at Southern Television's new £2½ million colour studios at Southampton

62 Southern Television's Film Department

When the new Southern Studio Centre was designed careful consideration was given to the siting of film facilities.

The centrepiece of the film department is the projection area, which services a 16 mm preview theatre, a 35 mm preview theatre and a dubbing suite. The preview theatres give straight-forward projection on to a screen, whilst the dubbing theatre uses back projection. This has enabled all the equipment, projectors, transfer/recording racks, to be centralized in one area. Also available is a complete rock and roll dubbing system.

Adjoining are seven film cutting rooms for film editing, each one self-contained with its own equipment, and a film joining area for film assembly.

Adjoining the dubbing theatre is the commercial film area which houses the commercial film vault and film assemblers. The complete operation of commercial and feature film assembly and film storage is carried out in this area, and access is provided to the preview theatre for film viewing.

The film processing plant is close at hand to the film editors, which enables film to be passed to them with the minimum of delay.

Southern Television is one of the few television contractors which carries out its own colour film processing. After several months of research and tests on colour film stocks and processing equipment, it was decided that the Agfa-Gevaert range of colour film stocks were the most suitable for the company's use. There are two types of colour reversal stocks– T.600 which is a slow film with fine grain and ideal for specialized filming, and T.605, which is used mainly for newsreels. This is a fast stock which can be forced up to a speed of 400 ASA.

The processing plant is of American manufacture, namely PAKO. It was chosen for its simplicity in operation and the sturdiness of its manufacture. Warm up time each morning for the plant is approximately 10 minutes, and 35 minutes later film can be coming off the plant at a speed of 50 ft a minute. Processing averages between 20,000 and 25,000 ft of colour film per week.

Southern Television programme film is supplied by three 16 mm sound-film units, and a corps of freelance cameramen.

Left: Part of the Film Department at Southern Television's new £2½ million colour studios at Southampton

Below: PAKO 16 mm colour film processing equipment in operation at Southern Television's new £2½ million colour studios at Southampton

63 Southern Television's Colour Outside Broadcast Unit

Southern's colour outside broadcast unit, built by the Company, at an initial cost of £225,000 in 1968, is equipped with four Mk VII colour cameras mounting Rank Taylor Hobson zoom lenses.

It is built on a Bedford VAL chassis powered by a 145 BHP six cylinder diesel engine and fitted with power steering, five speed gearbox, two-speed back axle and four braking systems. Fibreglass has been used extensively in the construction of the vehicle body; 34 ft long, 8 ft 2½ in wide and 10 ft 11 in high. Besides offering advantages in strength and lightness, this material is also impervious to corrosion—an important consideration as the unit will often operate in the salty atmosphere of coastal areas.

Internally the vehicle is divided into three compartments; sound, production, and vision control.

Each compartment has its own heater/cooler unit to afford precise area-by-area control of temperature.

The sound control system is a Pye 24-channel sound-mixing desk with fold-back, public address and echo facilities on every channel. Comprehensive communications facilities and reel-to-reel tape-recorder and a cassette-type tape machine are also provided. The Sound compartment is equipped with individual 8 in camera picture monitors plus a transmission monitor. One of the camera monitors may also be used for pre-view purposes. A two-way UHF radio link with floor managers is available.

The vision mixing equipment, manufactured by EMI, is a seven input unit of the A–B mix and cut type and is fitted with Richmond Hill special effects equipment for wipes and inlay requirements. Picture monitoring for production purposes is provided by six Sony 9 in monitors and one Rank Cintel 19 in colour monitor.

The vision control compartment is equipped with four Pye 14 in monitors and two Rank Cintel 19 in colour monitors. Additional monitoring of sound and vision is provided at the supervisory engineer's position by means of a peak programme meter and waveform monitor. This control position also contains a six-line, 11 extension PBX for control line circuits. Both real-time and countdown clocks are provided for the Production Assistant.

On the vision control desk two operational positions are manned by either two vision control engineers or one vision control engineer and a lighting supervisor, depending on programme requirements. Picture matching is carried out by reference to picture monitors and waveform displays show the red, green and blue outputs from the cameras and the fully encoded output. Test facilities include grey scale, sine squared pulse-bar and sawtooth generators and a Pluge unit is provided to permit the accurate setting of picture monitors.

Across the rear of the vehicle is the main equipment racking, housing camera control units and power supplies, two Marconi pulse generators with genlock and colour lock facilities, Pye vision distribution amplifiers, video patch panels, mains power control unit etc. The mains control unit provides metering of voltage, current and frequency of the incoming mains supply and contains overload circuit breakers for all equipment supplies. Three Berco automatic voltage regulators are housed in the near-side skirt of the vehicle, two of these are operational and the third is a spare which may be switched into circuit on the mains control unit in the event of failure. At the rear near side of the vehicle the vehicle termination panel is housed and all sound, vision and talk-back cables into and out of the unit are connected here. Immediately adjacent to the termination panel is a Clark Engineering pneumatic telescopic mast which extends 33 ft to carry aerials for the off-air receiver and the UHF talk-back transmitter and receiver.

Completing the Outside Broadcast Unit's facilities are a mobile Ampex VR 1200 B colour videotape machine and three mobile EMI ML4A colour microwave links mounted in separate vehicles.

Southerner, believed to be the world's first television outside broadcast boat, has recently been converted for full colour operation. This vessel, built originally for the Royal Navy as a Proud-Class MTB, is 71 ft 6 in in length, has a 20 ft beam and draws 4 ft 6 in of water. With her twin 2000 hp Armstrong Siddeley gas turbine engines, she is capable of a top speed of 34 knots and can carry 3000 gallons of fuel, sufficient for a 12 hour run of 350 miles at full speed. Additionally, she mounts a 200 hp General Motors diesel engine which alone can give her a speed of 10 knots and is used for slow speed cruising and manoeuvring.

Southerner was acquired by Southern Television in 1965 for monochrome outside broadcast coverage of such events as Cowes Week, the Fastnet Race and the Powerboat Races. She played a major part in the ITV broadcasts on the return of the round-the-world yachtsmen Sir Francis Chichester and Sir Alec Rose.

Converting her to colour has been a major task, only just accomplished in time for the August 1970 Cowes Week.

Two Marconi Mark VII colour cameras are mounted on specially constructed pedestals fixed to the deck on anti-vibration matting and have guard rails and safety harnesses for the cameramen. Each camera is equipped with a Rank Taylor Hobson zoom lens and is protected from salt water spray by a specially designed camera cover. To guard against condensation, warm air from the apparatus room below deck is ducted into the camera covers.

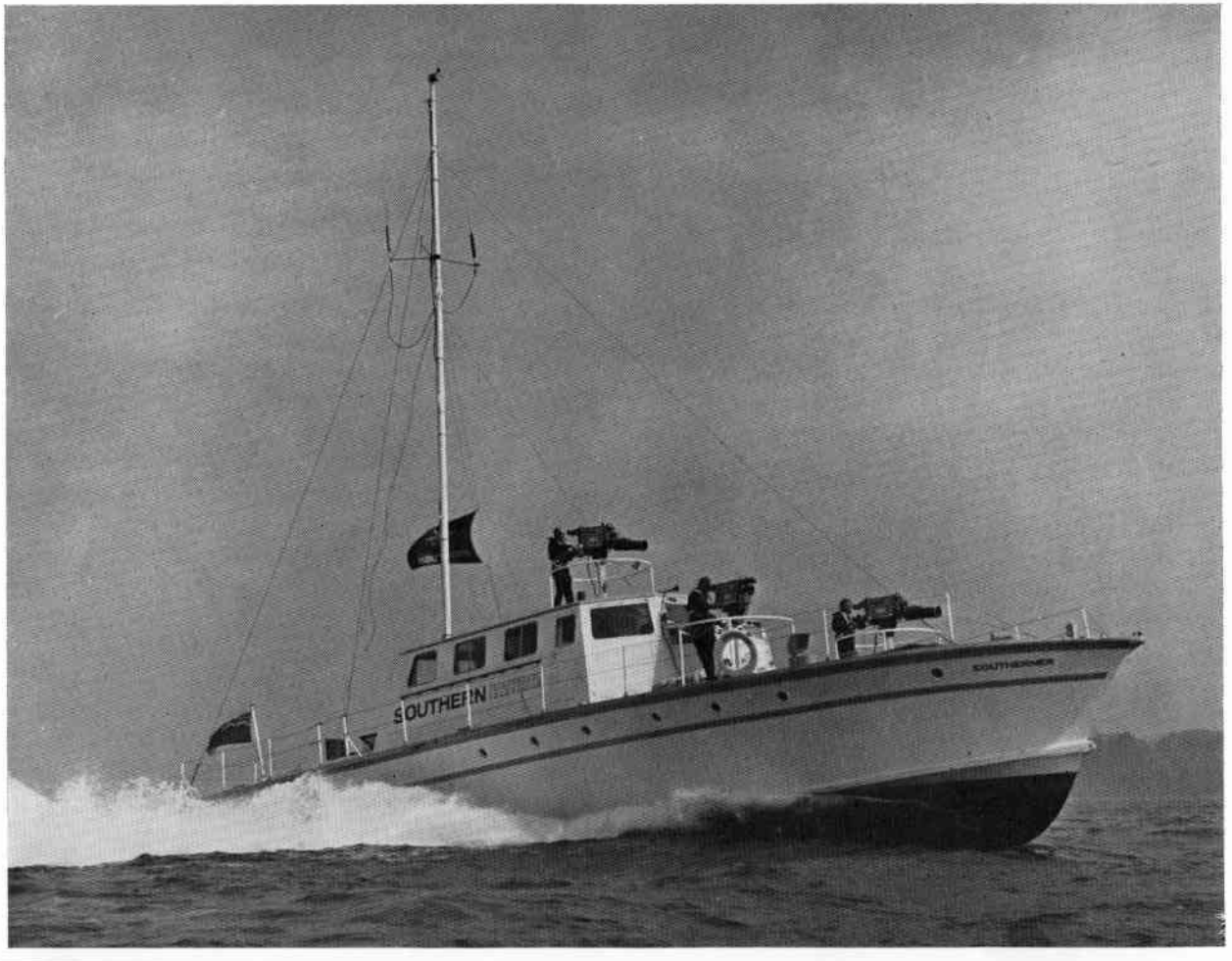
The apparatus room houses the camera control equipment, Marconi picture and waveform monitors, synchronizing pulse generators, colour coders, distribution apparatus and Rank Cintel picture monitors. An operational desk is provided for the control of camera iris, gain, black level and colour balance. Alongside is an Ampex VR1200 colour video tape recorder which is used to record programmes for later transmissions and to play recorded inserts into live programmes, which may be fed to receiving stations on the shore via two EMI ML4A micro-wave links.

These links, mounted in the apparatus room, have been extensively modified for use on *Southerner*. The klystrons have been removed from the transmitter heads and now form part of an aerial unit fixed on top of the 45 ft mast. This unit, specially designed for *Southerner* by S. M. Laboratories of Southsea, incorporates new and advanced techniques. The klystrons, one for vision and the other for sound, are fixed 2 ft 6 in apart on a cross-member and feed directly into directional couplers and thence to the polyroid aerial. In this way maximum power from the klystrons, nominally 2·8 watts, is transmitted to the aerial and a remote indication of transmitted power is available in the apparatus room. The whole unit may be rotated through 360° by a reversible half hp electric motor and a 2250:1 reduction gear, all controlled from the deck. This enables the aerials to be kept on the proper bearing, with relation to the shore receivers.

The above-deck cabin has been converted into a television production control room. It incorporates a Pye 8-channel sound mixing desk, a 5 input colour vision mixer specially built by Southern Television engineers which gives cutting and mixing facilities, communications equipment enabling the Director and supervisory engineer to converse with the commentator, cameraman, the apparatus room, the bridge and the shore, 4 black-and-white picture monitors and 1 colour picture monitor.

A small commentator's cabin is built on the foredeck and has two black-and-white picture monitors, lip ribbon microphone and communications equipment.

Electric power for the equipment is generated by a Dale Electric 22 KVA diesel generating set housed in the main engine room.



'Southerner.' Southern Television's 71-ft outside broadcast vessel, pictured shortly before her conversion for colour operation. 'Southerner' now mounts two Mark VII colour cameras

65 Technical Developments at Yorkshire Television

Yorkshire Television

Yorkshire Television's main studio complex was designed specifically for colour television and 625-line operation, on a seven-acre site at Leeds. The centre incorporates production and technical areas, together with administrative offices in a self-contained unit. All the technical equipment in the studios and control areas has full colour capabilities. Two small presentation studios share a single Marconi Mk VII camera. There are three production studios: studio 2 of 1225 ft² (three Mark VII cameras); studio 3 of 4430 ft² (four Mark VII cameras); and studio 4 of 7650 ft² with five EMI type 2001 camera channels. The studios are equipped with computer type lighting control and provided with luminaires.

In addition to the central apparatus for processing and switching signals, a range of six telecine machines comprises three twin lens flying spot units and three multiplex Plumbicon machines. A suite of six RCA multistandard high band recorders is available with full electronic editing facilities. Two four-camera outside broadcast vehicles, using Mark VII cameras, and one monochrome unit are in use together with a mobile videotape facility.

During the operational lifetime of a studio centre various changes in practice and the introduction of colour operations require the company's engineers to develop a number of new techniques and equipment. Notes on a number of such developments are given in this section.

Cinemascope and Wide Screen Replay Facilities for Flying Spot Telecine

It is now very common for the feature films, which are transmitted, to be of Cinemascope or wide screen format.

Normal replay equipment as supplied by the manufacturers copes with these formats by a re-adjustment of horizontal and vertical scan to give the correct aspect ratio, with the picture size being determined by a compromise between losing information at the extreme left and right hand sides and having large blank areas at top and bottom of the frame–the familiar letter box effect.

Particularly troublesome are opening and closing titles and credits, which invariably occupy the full screen width.

In order to satisfy these conflicting requirements in a more satisfactory manner it was decided to modify the telecine equipment used for transmitting feature films to allow full control of picture size and also provide operational control of horizontal shift. Since it would be virtually impossible to provide these facilities in photo-conductive machines, due to registration variations and signal output variations as the scan amplitudes are varied, it was decided to modify flying spot machines.

The inherent problems in modifying this type of machine are:

1 Variation in after-glow characteristic with raster size changes.

2 Compensating for the effect of the film motion which provides part of the scan.

The first problem proved to be negligible in the case of our CFTH telecine since the Philips scanning tube used has exceptionally short after-glow.

The second problem required sophisticated circuit designs to ensure that the aspect ratio remained constant as the picture size varied and to also ensure that the vertical blanking tracked.

To provide the facilities required it was necessary to make minor adjustments to the scanning circuits and to provide an extra unit containing the necessary control circuitry and a replacement blanking generator. Sophisticated circuit design enabled the elimination of pre-set controls. The operational controls are as follows:

1 The push button selector to cater for the various aspect ratios encountered. These are:
1·33:1 (normal); 1·75:1; 1·85:1; 2·35:1; 2·55:1.
This selector automatically adjusts the scan sizes and blanking and puts in circuit the Zoom and Pan controls in all positions other than normal.

2 The Zoom control allows continuous adjustment of picture size between the point where the film is scanned fully, with large blank areas at top and bottom, and the point where the screen is fully filled and a portion of the film is not scanned.

3 The Pan control is provided in order that the Operator may choose the optimum horizontal framing. This control is electrically inter-connected to the Zoom control so that it is impossible to scan beyond the edge of the film. Thus if the Operator sets the Zoom for maximum picture size, Pans full left and then Zooms out, the picture centering is automatically re-adjusted.

The equipment has proved very satisfactory in service. It is normal to commence with full wide screen display of the titles and Zoom smoothly to full height for the remainder of the film unless the action demands a return to wide screen display.

A further improvement under investigation will allow the Zoom and Pan to be controlled from information recorded during a rehearsal of the film.

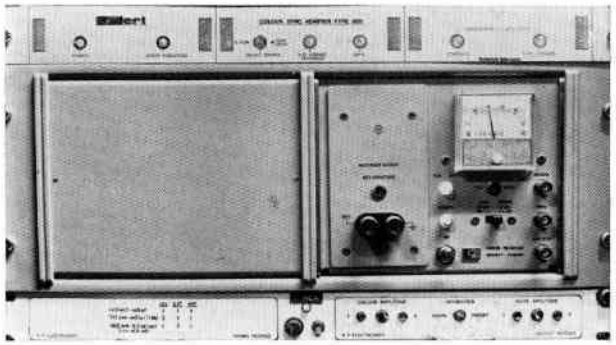
Video Tape Programme Sound Dubbing

The present trend in some broadcasting organizations, including Yorkshire Television, is to shoot certain programmes in segments for subsequent editing into a complete programme, in a manner similar to that normal in the film industry. The programme may be shot completely in the studio or on location using a Television OB unit or maybe a combination of the two. Our normal practice is to edit the material electronically so that the sound track on the edited video tape follows the picture splices correctly. Nevertheless, it is frequently necessary to enhance the sound track by the addition of music, sound effects and, perhaps, commentary, particularly where the original material was shot on location.

Various methods have been used for the re-recording of the sound track, including the use of synchronized audio recorders employing 16 mm magnetic film and synchronized $\frac{1}{4}$ in recorders.

However, considerable skill and effort is required to ensure that the sound track is maintained in synchronism with the picture.

The 'Palert' unit developed by Yorkshire Television to provide a device for verifying PAL colour signals before recording



The method which we have adopted at present simplifies the dubbing procedure and eliminates loss of sync risks completely.

The cue track performance of the RCA TR70–B VTR's which are in use in Yorkshire Television is sufficiently good to permit of its use as a second sound track.

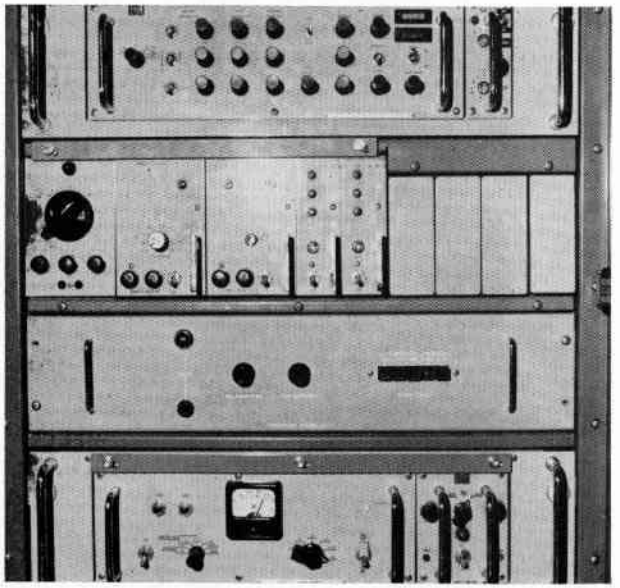
Minor modifications only were required to enable high quality transfer of audio signals from the main to the audio track. Thus, when we wish to enhance the sound track of a programme recorded on video tape we need only replay one VTR machine, route the second channel via a sound dubbing theatre where the extra material is added, and simultaneously record on the same machine's cue track. In order to avoid unnecessary transfers the programme is then transmitted using the cue track rather than further re-recording back to the main audio track.

In order to further simplify the operation and reduce the number of occasions when the 2 in VTR must be played, a $\frac{1}{2}$ in helical scan video tape copy is made immediately the edited video master is produced. This recording has super-imposed in the picture area time or footage indications, so that the director may at his leisure pre-view the tape and produce a dubbing chart listing the sound effects required and the points at which they are to be inserted. The same recording may then be used by the dubbing theatre personnel to rehearse the dubbing operation. This means that it is necessary to play the edited video master once only for the actual sound dub. However, should it be necessary, it is a simple matter to stop the VTR, roll back and repeat a section as desired, as in 'rock and roll' film dubbing. The method as described operates quite successfully, but as an added improvement we are investigating methods of adding a time code to the appropriate line of the field blanking in the 2 in edited video recording, so that a footage or time indication may be available from this recording, identical to that on the $\frac{1}{2}$ in copy.

Palert–a device for verifying PAL Colour Signals before recording

With current equipment it is possible to generate PAL colour signals in which the colour subcarrier is not correctly related to the remainder of the synchronizing signals. Whilst this does not normally have any serious effect in a live picture, such signals recorded on video tape, cannot normally be replayed in colour. In order to eliminate this risk, Yorkshire Television has developed 'Palert'. This equipment when connected to the input signal to a VTR machine, or indeed to any PAL colour signal, gives a continuous go, no-go indication of the presence of the colour burst, and more important, whether the vital subcarrier to field sync ratio is correct. Arrangements are being made for this equipment to be marketed commercially. A further development will verify the correctness or otherwise of the Bruch blanking sequence of the colour burst, and the PAL switch phase.

The Yorkshire Television Cinemascope unit installed in a CFTH telecine. The special unit is the third down in the rack below the control panel. A remote control panel for pan and zoom is situated on the operational desk



Television Camera Test Object

To produce high quality colour television pictures it is well known that it is essential to ensure the correct rendition of neutral objects. Common techniques utilize a multiple step grey scale occupying a large area of the camera field. Also provided with most grey scale charts is a small area of minimal reflectance for accurate setting of manual and automatic black level control circuits.

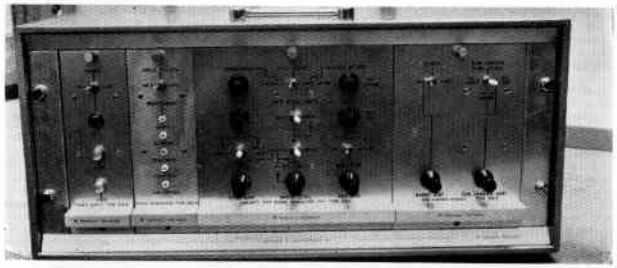
Our experience has shown two deficiences of this type of chart. Firstly, current television cameras contain unwanted colour variations across the camera field due to deficiencies in the light shifting optics, eg, dichromic tilt. There are also sensitivity variations in the lead oxide camera tubes. Additionally, flare and halation in the optical system and camera tube face plates causes unwanted colouration of small dark objects making it essential to set camera black level controls on a large area of 'absolute' black.

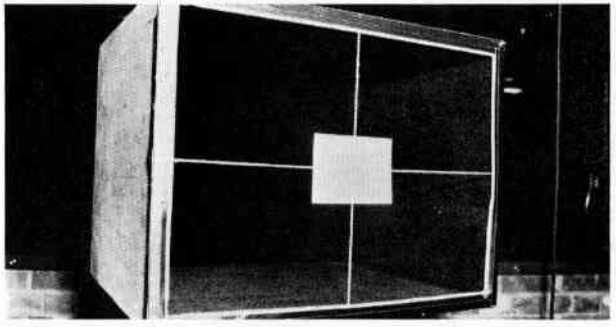
To overcome these problems a simple test object has been produced for test studio camera line-up. It comprises a box approximately 16 in by 12 in in frontal area and 16 in deep. The front of this box is open to the camera and the interior is lined with matt black material. The edge of the box is painted white and suspended in the centre of the aperture by two white cross-wires is a white card, approximately 2 in. square. When correctly framed this provides the camera operator with sufficient information to enable very accurate setting of camera neutral balance at black, white and, by operation of the iris control, other grey levels. Using the central white card ensures that the effects of colour shading are minimized and kept to the edges of the picture. The white cross-wires and the white box edge facilitate a quick check of the camera performance in respect of registration, although not sufficient for a full line-up.

Camera Video Test Processor

This device is used in conjunction with the previously mentioned camera test object. It is applied between the camera PAL encoder and a Vectorscope operating at high gain. The video signal corresponding to the test box should contain no chroma when the camera and encoder are properly adjusted. The processor selects from the video wave form any chroma from the black-and-white area separately according to the operation of a selector switch. This is achieved by a combination of video clipping and a band-pass filter. To improve visibility of chroma on the white square a gating signal is derived from the signal and applied to the Z input of the Vectorscope to suppress the CRT spot except when the white spot is being scanned.

The use of this item of equipment, together with the white box, facilitates very accurate checking of the camera and encoder settings ensuring complete freedom from unwanted colour shading due to camera or encoder mis-adjustment.





Linearity and Low Frequency Test Signal Generator

When Yorkshire Television commenced operating in 1968, although originally operating in monochrome, almost all the equipment was specified to be colour capable and needed to be checked for the important non-linear distortion which can arise. The radio link department also required equipment to generate 50 cycle and VLF test signals. Accordingly, it was decided to undertake development of a comprehensive non-linear and low frequency test signal generator. In view of the uncertainty existing at that time concerning the signals to be adopted for routine testing and to improve the equipment's usefulness for electronic development and maintenance purposes, the equipment was made as flexible as possible. Hence it will generate sawtooth or staircase signals on each line or one line in four, the intervening lines may be at black level or in grey level up to white. The video on intervening lines may be switched manually or automatically at any rate from 50 Hz to 0·04 Hz. The entire signal may be switched from normal level to +3 dB. Synchronizing pulse level is continuously variable from zero to greater than normal level. Subcarrier signals can be added on the staircase signal or on all lines at any desired level, also a standard subcarrier reference burst may be added at any desired level. The drive signals may be generated internally or derived from an external SPG. Suitable manipulation of the controls allows generation of any monochrome or colour test signal from a continuous grey level through 50 Hz and VLF test signals to a full gated staircase with super-imposed chroma and burst.

Above: Linearity and low-frequency test signal generator for general purpose checking of colour equipment

Below: Simple test object used by Yorkshire Television for test studio camera line-up. It comprises a box about 16 in by 12 in in frontal area and 16 in deep

Postscript

This booklet has described and illustrated only a few aspects of the continuous work of developing and improving the colour and/or monochrome television services provided by Independent Television throughout the United Kingdom, the Isle of Man and the Channel Islands.

Further information on the engineering activities of the Independent Television Authority can be obtained from: Alan James MBE, Head of Engineering Information Service, Independent Television Authority, 70 Brompton Road, London SW3

Information on the engineering activities of the programme companies should be obtained from the Chief Engineers at the following addresses:

Anglia Television Limited, Anglia House, Norwich NOR 07A

ATV Network Limited, ATV Centre, Bridge Street, Birmingham 1

Border Television Limited, Television Centre, Carlisle CA1 3NT

Channel Television, The Television Centre, St Helier, Jersey, Channel Islands

Grampian Television Limited, Queen's Cross, Aberdeen AB9 2XJ

Granada Television Limited, Granada TV Centre, Manchester M60 9EA

HTV (Harlech Television Limited), HTV Television Centre, Cardiff CF1 9XL

London Weekend Television Limited, Station House, Harrow Road, Wembley, Middlesex

Scottish Television Limited, Theatre Royal, Hope Street, Glasgow C2

Southern Television Limited, Southern Independent Television Centre, Northam, Southampton SO9 4YQ

Thames Television Limited, Teddington Studios, Teddington Lock, Teddington, Middlesex

Tyne Tees Television Limited, The Television Centre, City Road, Newcastle upon Tyne, NE1 2AL

Ulster Television Limited, Havelock House, Ormeau Road, Belfast BT7 1EB

Westward Television Limited, Derry's Cross, Plymouth

Yorkshire Television Limited, The Television Centre, Leeds LS3 1JS

Independent Television News Limited, ITN House, 48 Wells Street, London W1P 3FE

Independent Television Companies Association Limited, Knighton House, 52–66 Mortimer Street, London W1N 8AN

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