Viewpoint

A CRUCIAL ROLE

An electrical engineer, as defined in the Oxford Dictionary, is one skilled in the construction, maintenance, etc of electrical apparatus. But a better definition would be a person who develops and adapts new scientific discoveries for the good of mankind.

Therefore the time is fast approaching, if it is not here already, for the electrical engineer and his Institution to take the lead in a field that will affect the structure of society as we know it today. This field is the automation of the office, the electronic office, the office of the future or the less paper office, whichever term one chooses for the developments that are already taking place in the office due to the introduction of electronic technology into the traditional, people intensive, white collar work area.

In this area there will be the so-called coming together of the various disciplines of electrical engineering, i.e. computing, communications and the man/machine interface between these systems. Systems such as electronic PABXs, communicating word processors, digital voice storage systems and high speed information transmission link, perhaps on optical fibre cable, are at present, and will more so in the near future, play an increasing role in the way firms do their business. This will affect the office worker in particular and society in general.

The responsibility of the engineer to the society in which he lives is to ensure, firstly, that society should understand the changes that are being made to its way of living by the various technologies and, secondly, to see to the implementation of the chosen technology in a way that will bring the maximum benefit to the society. It must be accepted that in any radical change such as the one now being brought about in the office environment there will be confusion and a certain amount of disruption to the structure of the society, but it is again the duty of the engineer to see to it that these problems and disruptions are minimised.

One of the main problems in this field is that there are many people and organisations, state, semi-government and private, involved. This has led to a number of different directions being followed by the South African Post Office (teletext and X25 communications) computer suppliers (electronic mail and communicating word processors using various protocols and keyboard sets) and other suppliers of communications equipment and dictation systems. This has, together with the shortage of the required skilled personnel caused confusion to present and prospective users of these technologies. A confusion that our country cannot afford from either wasted money or manpower points of view.

There is an urgent need, therefore, for an organisation, either state or private, to co-ordinate and give guidance to the business community and government as to which direction they should follow. The South African Institute of Electrical Engineers is in an ideal position to fulfil this need as it would be acceptable to all the parties concerned, the South African Post Office, the computer industry and the private sector.

E Levin, *PrEng, MSc (Rand), Graduate SAIEE*

(The views expressed in this Editorial are those of the author, and do not necessarily reflect the views of the Council of the South African Institute of Electrical Engineers.)

Symposium on Opto-Electronics and its Applications

This Symposium which was attended by 89 delegates was held in Kelvin House, Johannesburg on 29 November, 1978. The Symposium was opened by K A H Adams, President, and the closing address was given by D H Mills, Vice-President.

Organising Sub-Committee

P L Swart (Chairman), T V Peter, H D Hölscher, T Y Poole (Secretary)

Of the twelve papers presented, four are to be published in full in the October and subsequent issues of the *Transactions*. The titles and synopses of the other papers presented at the Symposium are shown below:

Optical fibres for communications and Electroluminescent sources and detectors for lightwave communciations J S Vermaak.

Miniature high-pressure high-gas discharge lasers by H M·von Bergman.

Opto-elektroniese toepassings van ladingsbeheerde-elemente (CCDs) deur P Rademeyer.

The use of dielectric thin film in electro-optics by E van Rooyen.

A high speed optically isolated analogue to digital converter by G F W Woodhouse.

Opto-electronics in electromagnetic distance measurement by H D Hölscher.

A high speed electro-optical recorder by Dr D E Procter.

Lightwave Communications

J S Vermaak* *MSc (Maths) MSc (Physics) DSc (Pta)*

SYNOPSIS

Lightwave communcations today stands at the threshold of widespread use. In recent years significant advances in all the major components that make up the communication link; the *light sources* in the transmitter, the *transmission medium* and the *photo detectors* in the receiver, have been achieved.

This talk concerns all three of these major components of the communication link and will be presented in two parts.

(1) Optical fibres for communications

The high interest in optical fibre as communications medium is primarily a result of its high data rate capacity through a small diameter optical wave guide. The attenuation profile of a fibre optical wave guide does not depend on modulation bandwidth as the profile of conventional coaxial wave guide does. Consequently, significant size advantages over conventional coaxial cable are accrued for data rates beyond a few magabits per second. Other attractive features are: the solid state source of optical energy can be directly coupled to the wave guide; reception is completed with solid state detectors that are readily interconnected to conventional electronic circuitry; the communication channel is immune to external electrical noise disturbances.

The fabrication and materials processes necessary to produce low loss and low dispersion fibres at low cost will be discussed. The two main sources of dispersion — multimode and material dispersion — will be discussed as well as methods to reduce or eliminate it. Furthermore, the four principal contributors to attentuation loss — material absorption, material scattering, wave guide scattering and radiation loss, will also be discussed.

(2) Electroluminescent sources and detectors for lightwave communications

The second part of this talk concerns the other two components of the communication system — the light source and detector. One of the major requirements for an optical fibre lightwave communication system is the compatibility with one another of the light source, optical fibre and detector. Fortunately, over the last decade, semiconductor lasers and light emitting diodes as well as semiconductor detectors have been developed that inter alia meet this requirement. This talk will thus discuss the current status of semiconductor light sources — both coherent and incoherent — as well as photo detectors which fulfills all the requirements for lightwave communications through an optical fibre.

SINOPSIS

Liggolfkommunikasie staan tans op die punt om wyd toegepas te word. Daar is die afgelope aantal jare betekenisvolle vooruitgang gemaak in al die hoofkomponente wat die kommunikasieskakel uitmaak; die *ligbronne* in die sender, die *transmissiemedium* en die fotodetektors in die ontvangstoestel.

Die praatjie handel oor al die hoofkomponente van die kommunikasieskakel en word in twee dele aangebied.

(1) Optiese vesels vir kommunikasie

Die groot belangstelling in optiese vesels as kommunikasiemedium is hoofsaaklik toe te skryf aan sy vermoë om 'n hoë datatempo te behartig deur 'n optiese golfleiding met 'n klein diameter. Die verswakkingsprofiel van 'n optiese golfleiding is nie so afhanklik van modulasiebandbreedte soos die profiel van 'n konvensionele koäksiele golfleiding nie. Gevolglik is daar aansienlike groottevoordele bo die gebruiklike koäksiele kabel vir datatempo's bokant 'n paar megabisse per sekonde. Ander aantreklike eienskappe is: die vastetoestandbron van die optiese krag kan regstreeks aan die golfleiding gekoppel word; die ontvangs word behartig deur vastetoestandetektors wat maklik inskakel by gebruiklike elektroniese kringe; die kommunikasiekanaal word nie deur elektriese geruissteurings van buite aangetas nie.

Die vervaardigings-en materiaalprosesse wat vereis word om lae verlies, laeverspreidingsvesels teen 'n lae prys te maak sal bespreek word. Die twee hoofverspreidingsoorsake — multimode-en materiaalverspreiding — sal ook bespreek word asook wyses waarop dit verminder of uitgeskakel kan word. Die vier hoofoorsake van verswakkingsverlies, nl.; materiaalabsorbsie, materiaalverstrooing, golfleidingsverstrooiing en stralingsverlies sal ook bespreek word.

(2) Elektroluminessente bronne vir liggolfkommunikasie

Die tweede deel van die praatjie skenk aandag aan die ander twee dele van die kommunikasiestelsel — die ligbron en detektor. Een van die hoofvereistes vir 'n liggolfkommunikasiestelsel deur optiese vesels is die aanpasbaarheid van die ligbron, optiese vesel en detektor met mekaar. Daar is gelukkig gedurende die afgelope dekade halfgeleierlasers en ligstralende diodes asook halfgeleierdetektors ontwikkel wat onder andere ook aan hierdie vereiste voldoen. Hierdie deel van die praatjie sal dus handel oor die hiudige stand van halfgeleierbronne — sowel koherent as nie-koherente lig — en fotodetektors wat aan al die vereistes vir liggolfkommunikasie deur 'n optiese vesel, voldoen.

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Miniature high-pressure high-power gas discharge lasers

H M von Bergmann* *PhD (Natal)*

SYNOPSIS

This paper describes the design, technology and evaluation of miniature, rugged low-cost devices which use high-pressure photoionization stabilized discharge concepts. The centimetre-long lasers have plasma volumes of $\leqq 0,05$ cm³ and provide 100 kW (spatially uniform) pulses of 1–20 ns duration. These devices will have applications to a wide range of spectroscopic, calibration, radiometric and ranging problems. We are concentrating primarily on the fabrication of nitrogen, rare-gas-halide (excimer) and carbon dioxide lasers. These systems are energized by fast Blumlein pulsers switched by compact transmission-line-mounted low-inductance spark gaps. Sealed-off 10–20 mm devices will operate at repetition rates of up to ~100 Hz and generate average powers of up to ~5 mW. The proven stabilization and construction techniques represent a significant step towards the development of rugged, low-cost pulsed gas-discharge lasers. The technology is very flexible and can be adapted to a wide variety of other high power laser systems.

SINOPSIS

Die referaat beskryf die ontwerp, tegnologie en waardepaling van stewige goedkoop miniatuurtoestelle wat van gestabiliseerde hoëdrukfotoioniseringsontladingsbeginsels gebruik maak. Die sentimeterlange lasers het plasmavolumes van $\leqq 0,05$ cm³ en verskaf 100 kW pulse wat 1–20 ns duur en ruimtelik eenvormig is. Die toestelle kan vir 'n groot verskeidenheid spektroskopiese, kalibreer-, radiometrieke en aftastingsdoeleindes gebruik word. Die aandag word hier in die besonder bepaal by die maak van stikstof-, edelgas-halide (eksimer)-, en koolstofdioksiedlasers. Die stelsel word bekrag deur vinnige Blumlein-pulswerkkers wat geskakel word deur laeïnduktansievonkopeninge wat in die transmissieleiding gemonteer is. Verseëlde 10–20 mm toestelle werk teen wisseltempo's van tot ~100 Hz en wek gemiddeld ~5 mW krag op. Die bewese stabilisering en konstruksietegnieke is 'n aansienlike stap vooruit vir die ontwikkeling van stewige, goedkoop, gasgepulsde ontladingslasers. Die tegnologie is baie aanpasbaar en kan aangepas word vir 'n groot verskeidenheid ander hoëkrag miniatuurgasontladinglasers.

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Opto-Elektroniese toepassings van ladingsbeheerde-elemente (CCDs)

P. Rademeyer* *Pring, DSc (Pretoria)*

SINOPSIS

Sedert 1970 het die ladingsbeheerde-element (LBE) of 'CCD' fenomenale opgang gemaak as beeldprossesseerder, sein-prosesseerder en geheue-element.
In hierdie referaat sal daar veral aandag gegee word aan die optoelektroniese toepassings van LBEs in die beeldprosesseringsveld.
Die produksie-area toepassings van *Opto-LBEs* is die volgende:

1.1 Standaard TV — matrikse
1.2 Lae ligvlak beeldmatrikse
1.3 Infrarooi-beeldmatrikse

In die volgende paragrawe sal hierdie drie gebiede verder ondersoek word aan die hand van praktiese ontwerpe en voorbeelde van implementering.

SYNOPSIS

Since 1970 charge-coupled devices or CCDs have gained phenomenal acceptance as image processors, signal processors and memory devices.
In this paper attention is devoted mainly to the opto-electronic application of CCDs in the field of image processing.
Production area applications of opto CCDs are as follows:

1.1 Standard TV matrixes
1.2 Low light level image matrixes
1.3 Infra-red image matrixes

In the following paragraphs these three areas will be further discussed in view of practical designs and examples of applications.

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A high speed optically isolated analogue to digital converter

G F W Woodhouse* *PrEng, BSc (Eng), MSc (Eng), MSAIEE*

SYNOPSIS

This paper describes a high speed optically isolated analogue to digital converter (ADC). The ADC is used to digitize radio astronomy signals prior to processing in a digital correlator [1, 2].
The ADC is somewhat special purpose since the signals are quantized into only 3 levels and coded with 2 bits.
In order to minimize contamination of the analogue signals by the digital circuitry, the ADC is divided into two sections which are isolated from each other by means of optocouplers.
The paper discusses some of the merits of optical isolation and compares three different methods of optically isolating the analogue and digital circuitry.
The actual performance of the ADC is discussed and some improvements are suggested.

SINOPSIS

Hierdie referaat handel oor 'n hoëspoed- opties geïsoleerde analoog-syfer-omsetter (ASO). Die omsetter word gebruik om radioastronomieseine te versyfer voordat dit in 'n digitale korreleerder verwerk word [1, 2].
Die ASO is ietwat eendoelig want die seine word slegs tot 3 peile gekwantiseer en tot 2 bis gekodeer.
Ten einde kontaminasie van die analoogseine deur die syferbaanwerk te minimiseer is die ASO in twee dele verdeel, van mekaar geïsoleer, dmv optokoppelaars.
Die referaat behandel die meriete van optiese isolasie en vergelyk drie verskillende metodes om die analoog- en syferbane opties te isoleer.
Die werklike werkverrigting van die ASO word bespreek en 'n paar verbeteringe word voorgestel.

* Chief Research Officer, National Institute for Telecommunications Research of the South African Council of Scientific and Industrial Research

The use of dielectric thin films in electro-optics

E van Rooyen* *D Sc (Pretoria)*

SYNOPSIS

The optical properties of an isotropic thin film is defined by the complex refractive $\tilde{n} = n - ik$ and the geometrical thickness of the layer. For optical applications only materials with small k values are utilized such as MgF_2, Z_nS, SiO_2, Al_2O_3, TiO_2 etc. The deposition characteristics of the material should be reproducible to achieve thin films with desired optical and mechanical properties.

The refractive index of the thin film may vary up to 15 per cent with thickness. These layers may be used succesfully provided the refractive index profile is known and reproducible. Typical applications are anti-reflection and low loss fibre optics.

Applications in electro-optics are:

- Beamsplitters; high reflectivity mirrors; bandpass and edge filters; anti-reflection; low loss fibre optics; polarizers.

Integrated optical systems use thin film components for:

- light generation: GaAs lasers
- waveguides
- modulators

For all the above components the optical properties of the materials used is important. A number of examples are discussed to show how these characteristics are utilized to achieve the desired result.

SINOPSIS

Die optiese eienskappe van isotropiese dun films word gegee deur die komplekse brekingsindeks $\tilde{n} = n - ik$ en die dikte van die laag. Vir optiese toepassings word slegs materiale met klein k waardes gebruik, soos MgF_2, Z_nS, SiO_2, Al_2O_3, TiO_2 ens. Die neerslageienskappe van die materiaal moet reproduseerbaar wees om films met die gewenste optiese en meganiese eienskappe te verkry. Die brekingsindeks van die dun film mag tot 15 per sent varieer met dikte. Hierdie lagies kan met sukses gebruik word indien die profiel van die brekingsindeks bekend is en reproduseer kan word. Tipiese toepassings is anti-refleksie en veseloptika met lae verlies.

Toepassings in elektro-optika is:

- Bundeldelers, spieëls met hoë reflektiwiteit, banddeurlaatfilters en onder bolaat filters anti-refleksie, lae verliese en veseloptika en polariseerders.

Geïntegreerde optiese stelsels gebruik dunfilmkomponente vir:

- ligopwekking: GaAs-lasers
- Golfleiers
- Modulators

By al die bogenoemde komponente is die optiese eienskappe van die materiale belangrik. 'n Aantal voorbeelde word bespreek om aan te dui hoe hierdie eienskappe gebruik word om die vereiste resultaat te bereik.

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A high-speed electro-optical recorder

D E Proctor* *BSc (Eng) (Rand) Graduate SAIEE*

SYNOPSIS

This paper describes some aspects of an electro-optical recorder that was designed and custom-built by a British contractor to serve a special purpose. The recorder is capable of recording simultaneously on five separate channels each having a bandwidth from dc to 5 MHz, in a manner which ensures that timing errors between all channels are less than 70 ns rms. Each recording may continue for 20 minutes without interruptions of any duration. On the other hand, our requirements for amplitude-fidelity were not very stringent and the specification stated that only four levels of amplitude need to be resolved clearly. Although this recorder is an analog device we may state the recording rate as being equivalent to 2×10^8 bit/s. A facility for replaying the recorded data at very low rates that were less than one percent of the recording speed were of cardinal importance in the particular application for which the recorder was intended.

Data are recorded as variations in density of very fine grain film that has been exposed by light from low power Helium-Neon lasers. The intensity of the beams of light emitted by the 2 mW lasers is modulated by Bragg acousto-optic modulators and the beams are then scanned across the width of the 35 mm film by means of a rotating mirror having 18 facets. The film is transported at a speed of 30 cm/s in a direction perpendicular to the direction of the scan. Two lasers and two Bragg modulators are used to record six channels. Each Bragg modulator is driven by the sum of three signals which are injected at different frequencies in the VHF band. Carriers at 180 MHz, 210 MHz and 240 MHz are modulated individually by the incoming data from three channels and the double sideband, suppressed carrier output of three diode-ring modulators is summed and applied to the Bragg acousto-optic modulators, which then deflect the single, incident laser beam through three angles, each a function of the modulated carrier frequency, so that each of the emergent beams has been intensity-modulated by the data. Thus each acousto-optic modulator provides a vertical stack of three independently modulated emergent beams that are scanned horizontally across the film by the rotating mirror. The two lasers are arranged so that they emit beams that are polarized orthogonally. This permits the use of a polarization beam splitter to combine the beams that emerge from two acousto-optic modulators so that a vertical stack of six beams may be scanned simultaneously.

To retrieve the recorded data, the processed film is scanned mechanically past a stationary laser beam, so that the variations in film density recorded on the film modulate the intensity of the incident beam, which has been focussed onto the film by means of a cylindrical lens so that the beam is narrow enough to provide the required resolution, but high enough to illumunate many tracks simultaneously. The light transmitted by two tracks is focussed onto two photodiodes in a way which permits the sixth track, which carries timing information, to be played back simultaneously with one of the data tracks.

The overall transference is quite linear, but signals are degraded by the graininess of the film which causes noise to be superimposed on the replayed signals. The tangential amplitude of the noise amounts to 10 per cent of the maximum signal, so that ten levels of amplitude are discernable. The device employed to replay the data is inelegant in that it scans the film mechanically past a stationary beam, but this inversion does have the benefit that an inexpensive camera lens could be used in the replay unit. The recorder certainly copes with a very high data-rate which is only now becoming state-of-the-art for tape-recorders, which use 56 tracks to obtain the same overall data-rate. The optical recorder is not portable and it is allegedly somewhat temperature-sensitive. Later models may make use of ferrochromic materials for the recording medium so that the tedium of film-processing could be avoided, and recordings could be erased and then the medium could be used repeatedly.

SINOPSIS

Die referaat beskryf sommige aspekte van 'n elektroöptiese opnemer wat vir 'n besondere doel deur 'n britse kontrakteur ontwerp en volgens spesifikasies gebou is. Die opnemer kan gelyktydig op vyf afsonderlike kanale wat elk 'n bandwydte van gs. tot 5 MHz het, opneem sodat die tydhoufoute tussen al die kanale minder as 70 ns wgk. Elke opname kan vir 20 min ononderbroke duur. Daarteenoor was die vereistes vir amplitudegetrouheid nie baie streng nie en die spesifikasie het aangedui dat slegs vier amplitudepeile duidelik gedefinieer moet word. Hoewel die opnemer 'n analogtoestel is kan ons beweer dat die opneemtempo gelyk is aan 2×10^8 bisse/s. Dit was van primêre belang by die doel waarvoor die opnemer gebruik sou word, dat die opgenoemde data teen 'n baie lae spoed, tot minder as een honderdste van die opneemspoed, teruggespeel kan word.

Die data word vasgelê as digtheidswisseling in film met 'n baie fyn grein wat blootgestel is aan die lig van twee Helium-Neonlaekraglasers. Die intensiteit van die ligstrale wat deur die 2 mW-lasers uitgegee word, word gemoduleer deur Bragg akoesties-optiese modulators en die strale word dan afgelas oor die breedte van 'n 35 mm-film deur 'n draaiende spieël met 18 vlakke. Die film word aangedraai teen 'n spoed van 30 cm/s in 'n vertikale rigting teenoor dié van die straalbeweging. Twee lasers en twee Bragg-modulators word benut om ses kanale op te neem. Elke Bragg-modulator word aangedryf deur die totaal van drie seine wat teen verskillende frekwensies op die BHF-band ingevoer word. Draglowe van 180 MHz, 210 MHz en 240 MHz word afsonderlik gemoduleer deur die inkomende data van drie kanale en die dubbelsybandlewering met onderdrukte draer van drie diode-ringmodulators word gesommeer en deurgevoer na die Bragg akoesties-optiese modulators. Hulle deflekteer die enkele invalstraal deur drie hoeke, elk 'n funksie van die gemoduleerde draerfrekwensie sodat elk van die uitvalstrale intensiteitgemoduleerd is deur die data. Elke akoesties-optiese moduleerder gee dus 'n vertikale stapel van drie afsonderlik gemoduleerde uitvalstrale wat ortogonaal gepolariseer is. Gevolglik kan 'n polariseerstraalverdeler gebruik word om die uitvalstrale van twee akoesties-optiese modulators saam te voeg, sodat 'n vertikale stapel van ses strale gelyktydig afgetas kan word.

Ten einde die opgeneemde data te herwin word die ontwikkelde film meganies afgetas deur dit voor 'n stilstaande laser verby te beweeg sodat die variasies in filmdigtheid wat op die film vasgelê is, die intensiteit van die invalstraal moduleer. Die straal word deur 'n silindriese lens op die film gefokus sodat die straal smal genoeg is om die vereiste definisie te gee maar tog wyd genoeg is om 'n aantal bane gelyktydig te belig. Die lig wat deur twee bane uitgestraal word, is op twee fotodiodes gefokuseer op sodanige wyse dat die sesde baan, wat die tydinligting bevat, gelyktydig met een van die databane teruggespeel kan word. Die algehele oorsending is heel linieêr, maar die seine word nadelig beïnvloed deur die greindigtheid van die film wat veroorsaak dat geruis op die teruggewonne seine gesuperimponeer word. Die tangensiale amplitude van die geruis beloop 10 per sent van die maksimumsein sodat 10 amplitudepeile waarneembaar is. Die toestel wat gebruik word om die inligting terug te speel is nie besonder verfynd nie omdat dit die film by 'n stilstaande straal laat verbybeweeg, maar dit hou die voordeel in dat 'n goedkoop kameralens gebruik kan word in die terugspeeleenheid. Die opnemer behartig 'n baie hoë datatempo wat op hede eers deel word van die bandopnemertegniek wat 56 bane vereis om dieselfde totale datatempo te bereik. Die optiese opnemer is nie draagbaar nie en is na bewering ietwat temperatuurgevoelig. Latere modelle kan dalk ferrochroomstowwe as opneemedium gebruik om die sleurwerk van filmontwikkeling te vervang. Die opnames kan dan ook uitgevee word en die medium herhaaldelik gebruik word.

Opto-Electronics in electromagnetic distance measurement

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SYNOPSIS

The use of Gallium Arsenide light emitting diodes as carrier sources in electromagnetic distance measuring (EDM) instruments is discussed. The basic operating principle of the electro-optic distance measuring system is presented and various aspects of near IR propagation, detection and system performance is treated.

SINOPSIS

Die benutting van Gallium arsenide-ligstraaldiodes as drabronne in instrumente vir die elektromagnetiese bepaling van afstand word bespreek. Die grondbeginsels waarvolgens die elektro-optiese afstandmetingstelsel werk word aangebied en verskeie aspekte van bykans IR-opwekking deteksie en stelselprestasie word bespreek.

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Some applications of opto-devices in power electronics

J D van Wyk*

SYNOPSIS

The application of opto-electronic isolating links in power electronic systems is discussed. Interfaces of this type with discrete components are examined according to their system applications. In the first instance the application of opto-couplers in forced commutated circuits, especially dc to dc converters and dc to ac convertors in power transistor technology is treated. Attention is then given to discrete electro-optical interfaces in present high voltage line commutated converters using thyristor technology. This is then followed by an analysis of the feasibility of opto-electronic interfaces integrated directly into power switching components. Progress in direct light activated high powered thyristors is then reviewed and finally problems and future developments in the field of opto-electronic interfaces in power electronics are discussed.

SINOPSIS

Die toepassing van opto-elektroniese isoleerders in drywingselektroniese stelsels word (in hierdie referaat) bespreek. Koppelvlakke van hierdie tipe wat opgebou is met diskrete elemente, word aan die hand van hulle onderskeie stelseltoepassings ondersoek. In die eerste plek word die toepassings van opto-koppelvlakke in dwingkommutasiebane, veral gs-gs en gs-ws omsetters met drywingstransistors, bespreek. Hierna word aandag gegee aan diskrete optiese koppelvlakke in hedendaagse toevoergekommuteerde omsetters vir hoëspanning, uitgevoer in tiristortegnologie. Dit word dan gevolg deur 'n analise van die uitvoerbaarheid van direkte integrering van opto-elektroniese koppelvlakke in die drywingskakelaars. Laastens word vordering in groot drywingstiristors met direkte ligbesturing in oënskou geneem, terwyl probleme en toekomstige ontwikkeling in hierdie veld bespreek word.

Interface problems in power electronics

In electronic systems used for the control of energy flow, a peculiar set of circumstances arise, which complicates the interfacing of the command generating (or information processing) and actual energy controlling (power processing) parts of the electronic system. The voltage isolation levels necessary extend to some 500 kV, while the high values of dI/dt and dV/dt coupled to the types of layout made necessary by the high power considerations, often cause severe interference problems in these systems. Since the information processing inputs in the system are often actuated by currents much less than one milliampère and voltages of the order of millivolts, the elimination of these problems sometimes proves extremely troublesome by conventional means.

To obtain an indication of the order of magnitude of capacitive pick-up problems, consider the specifications in Table 1 concerning the two most important switch technologies at present in use in power electronics, i.e. thyristor switches and bipolar transistor switches. The permissible stray capacitance for keeping the pick-up currents below 1 mA, should some part of the information processing electronics be coupled directly to the power electronics by normal means (transformer coupling), is calculated to be less than 2 pF and 1,0 pF for the thyristor switch and transistor switch.

Table 1 Capacitive pick-up in power electronics. (Typical values)

Type of switch	Voltage (V)	Switching time (μs)	dV/dt (V/μs)	Pick-up current (mA)	Stray capacitance (pF)
Thyristor	2 500	5	500	1	2
Transistor	250	0,25	1 000	1	1,0

Table 2 indicates that inductive pick-up problems might be just as severe. The high values of dI/dt are generated around the power switches themselves, while the final stages of the signal generating electronics cannot be placed too far away from these switches, since risetimes of less than 100 ns are often required at the input to the power switches. Therefore a value of magnetic path length of 20 cm as taken in Table 2 is fairly typical. In this case a loop of 0,32 cm^2 is sufficient for a pick-up of 100 mV interference if it falls within 20 cm magnetic path length of the main current flow. Obviously, these problems increase as the inherent power amplification of the power switch increases, since this decreases the power level of the final stage of the signal generating electronics, making these subsystems more susceptible to the induced currents and voltages.

Elimination of these effects by conventional means has been developed to a fine art in power electronics over the past decade. Output pulse transformers in thyristor equipment should be carefully shielded elec-

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trostatically. Arrangements of filters, magnetic shielding and balanced commoning have very often to be resorted to. These measures add considerably to the complexity and cost, while in some cases their practical limitations render them useless.[6] This will become evident from the subsequent discussion.

Table 2 Inductive pick-up in power electronics. (Typical values) (Pick-up area has been determined for N = 1, and magnetic path length of 0,2 m)

Type of switch	Current (A)	Switching time (μs)	dI/dt (A/μs)	Pick-up voltage (mV)	Stray inductance (nH)	Pick-up area (cm^2)
Thyristor	500	1	500	100	0,2	0,32
Transistor	500	1	500	100	0,2	0,32

The attractiveness of the use of opto-electronic isolation in the interface between signal electronics and power electronics lies in the almost total absence of electromagnetic pick-up during transmission of the signal through the fibres, the possibility of extremely low capacitance between input and output and the possibility of physical separation between input and output without significant effects on output risetime, thus effecting very high levels of voltage isolation. Opto-electronic isolation will be discussed in the following paragraphs with reference to both the structure of the interfaces and their typical power system applications, as follows:

(i) Opto-interfaces with discrete components
  (a) Application to high speed forced commutation converter technology
  (b) Application to high voltage converter technology
(ii) Opto-interfaces with the output integrated with the high power switch.

1 Opto-interfaces with discrete components

In these interfaces the optical isolation is obtained in one specific intermediate part, as shown in Fig 1. This idea was first suggested by Feinberg in 1966 for a model six-pulse converter[0], using GaAs- LEDs (radiation wavelength 900 nm) and p-i-n Silicon diodes as detectors, coupled through Perspex rods as light guides. During the next few years this idea was taken up for high voltage converters [5] as well as for isolation at lower voltage levels, incorporated into one single component namely the optical isolator. While the optical isolator is one single small component with a typical voltage rating of a few kilovolts, the fibre coupled systems are much more complicated, and used for ratings of many kilovolts. The circuit applications of these ideas differ considerably from each other.

1.1 Discrete opto-couplers in transistorized power switches

As pointed out in Table 1, transistor power switches operate considerably faster than thyristor switches, so that the requirements regarding capacitance between input and output are far more stringent for these applications. Present-day commercially-available optical isolators in discrete component form have not yet been developed specifically towards power electronic appli-

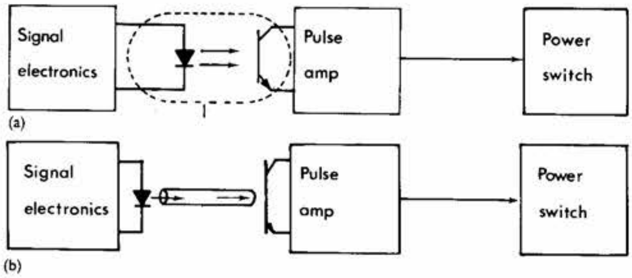


Fig 1 Discrete optical interfaces

cations, although it is believed that these types will shortly be available. Their voltage isolation levels (from 1 kV to 5 kV) are undoubtedly suitable for application in present day transistor switching technology, but the devices are low power units (at most 30 to 100 mW) with very slow switching speeds. Under some conditions it is possible to achieve total switching times of the order of 1 μs, but reference to Table 3 indicates 10 μs to be more of a typical value if on-off switching is necessary. The power transistors themselves switch within 1 μs, and this combines with the relatively high input-output capacitance of 0,4 pF of the opto-couplers, to limit the applicability to transistorized power switches to that of an intermediate isolator. As discussed below, circuit applications of transistor power switches fall into two classes, namely dc to dc converters and dc to ac converters. The motivation for the use of opto-couplers differs somewhat in these two cases.

1.1.1 Optical isolation in dc to dc converters with transistor switches

Fig 2(a) and (b) illustrate the two fundamental circuit configurations for dc to dc converters for down conversion and up conversion respectively ($V_1 > V_2$). Power system applications of these circuits always necessitates a current measurement as shown. Depending on the position of the current measurement in the circuit, as well as whether p-n-p or n-p-n switches are used, 16 fundamental circuit topologies for each of the configurations shown in Fig 2(a) and (b) result (32 in all). Practical experience in this field has shown that no particular one topology can be selected as the best. In practice the selection of any particular one may be dictated by a number of reasons. This may result in the selection of a topology where the current measurement and base drive circuitry do not refer to the same potential. In this case isolation between these two subsystems becomes necessary. Since the control system is mostly analogue in nature, due to considerations of cost and simplicity, the plane of isolation is mostly chosen at that level of information flow where the signal has already been converted to digital form, i.e. where the switching function to drive the power switch on and off has already been generated.

Only two alternatives for achieving this isolation exists, namely magnetic (mostly carrier frequency systems[11]) and optical. The last method is simpler and cheaper, especially from a production viewpoint, so that it is to be preferred. Two examples of how this can be applied is given in Fig 2(c) and (d), where the output from the current control system I is already in

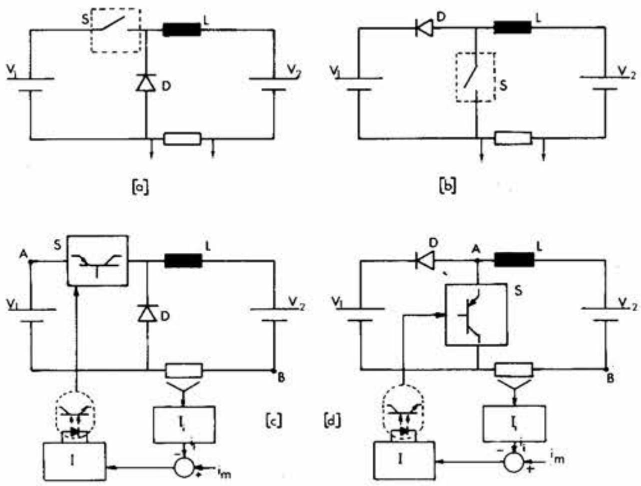


Fig 2 Schematic illustration of opto-coupling in some dc to dc converters

Table 3 Typical values of parameters for low power optical isolator

Voltage isolation (kV)	Input diode current (mA)	Output current (mA)	Delay time (µs)	Rise time (µs)	Storage time (µs)	Fall time (µs)	Capacitance in-out (pF)
1 to 5	35	4	3,0	5,0	0,5	5,0	0,4

the form of a binary signal. The low power levels concerned (Table 3) dictates considerable power amplification of this switching function in the power switch S. It should be noted that with A and B as common reference points for the power electronics and signal electronics respectively, these subsystems can be fed from V_1 and V_2 — eliminating extra power supplies (one of the reasons for choosing these two respective topologies). These techniques have been applied in our laboratory with success up to a level of some 15 kW in drives for battery-fed vehicles(12).

1.1.2 Optical isolation in dc to ac converters with transistor switches

Considerations concerning dc to ac converters are somewhat different. Two fundamental families of topologies exist: centre-tapped (or star point) configurations, and bridge configurations. Problems with isolation of signal electronics and power electronics are confined to the bridge configurations.

Fig 3(a) represents the configuration for a single phase bridge version of a dc to ac converter, where V_s represents a direct voltage source and v_o the ac output. It is evident from this figure that no matter what the reference potential chosen for the signal electronics, half the power switches in the system refer to another potential. Since the switches operate in pairs (for example S_1, and S_2, S_3 and S_4) it can be seen that the dV/dt requirements on the signal electronics are severe, whether p-n-p or n-p-n switches are used. Furthermore, as the number of power switches in the system have now increased, the use of magnetic isolation is even at a greater disadvantage than with dc to dc converters.

Again, the point of isolation can best be chosen at the stage where the switching function has already been generated by the control system, and only further power amplification is needed for driving the bases of the switching transistors.

Fig 3(b) gives an example of the application of this method to a three phase inverter feeding an induction machine from a dc supply. In this case the top three switches have been chosen as p-n-p-units and the bottom switches as n-p-n-units, in order to let the respective base-drive circuitry refer to the positive and negative rail. In a configuration with n-p-n-units throughout the considerations for opto-coupling remains the same, although the circuit configuration changes somewhat. These solutions have been applied in our laboratory up to a level of some 10 kW with success(12).

1.2 Discrete opto-coupling in power switches using thyristor technology

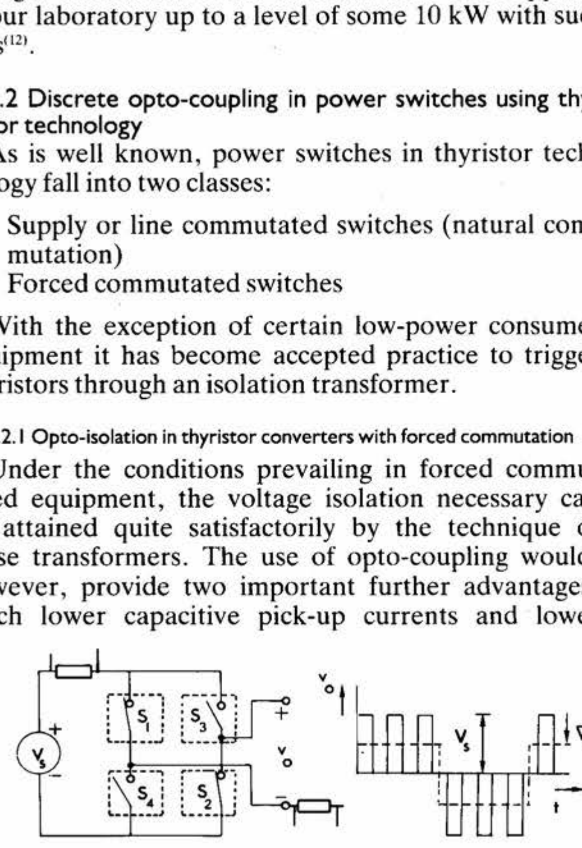
As is well known, power switches in thyristor technology fall into two classes:

(i) Supply or line commutated switches (natural commutation)
(ii) Forced commutated switches

With the exception of certain low-power consumer equipment it has become accepted practice to trigger thyristors through an isolation transformer.

1.2.1 Opto-isolation in thyristor converters with forced commutation

Under the conditions prevailing in forced commutated equipment, the voltage isolation necessary can be attained quite satisfactorily by the technique of pulse transformers. The use of opto-coupling would, however, provide two important further advantages: much lower capacitive pick-up currents and lower



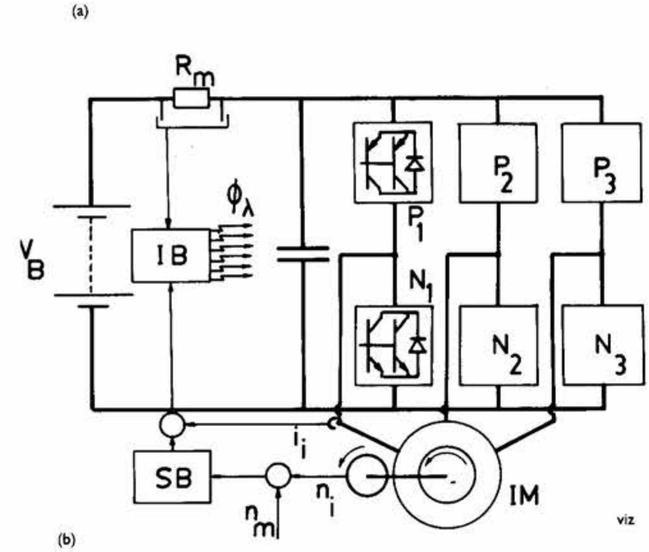


Fig 3 Schematic illustration of opto-coupling in dc to ac converters

magnetic pick-up voltages. Unfortunately the functioning of these forced commutated circuits require a gate signal for the thyristor for extended periods. As the repetition frequency at which these switches operate is variable in most cases, extending down to perhaps 1 Hz, this means that the isolated power supply necessary for the power amplification becomes too large, (refer to Fig 1(a) and 1(b)), introducing complications to neutralize the advantages obtained by opto-coupling. Furthermore, force commutated equipment cover the whole range of powers from 1 kW to 1 MW and in equipment below a few hundred kilowatt the cost of all the isolated power supplies is too high. In considering application of opto-coupling to this type of converter, it should also be kept in mind that the switching requirements require gate signal risetimes better than 1 μs and high initial amplitudes (>1A), so that the isolated gating supply is further complicated. All these factors have added up to such an extent that there has as yet been no extensive application of this method in forced commutated circuits.

1.2.2 Opto-isolation in thyristor converters with line commutation

In the case of converters with line commutation the considerations regarding isolated power supplies and total cost of equipment have favoured the application of opto-isolation. In fact, it was for this type of equipment that the idea was originally proposed[0]. In present day high voltage static converter equipment the limited voltage of one thyristor cell necessitates the use of a string of thyristors. It was the problems associated with obtaining the necessary voltage isolation at the increasing potential (> 20 kV) that prompted the growth of this application[5]. This technology has developed to the stage where it is applied in practice to great economic and technical advantage,[6,8] including the Canadian Nelson River Project's 1 800 MW, 500 kV second bipole unit[7].

Fig 4 gives a schematic representation of such an opto-isolated triggering system. As the optical power transmitted is again very low, pulse amplification is carried out right at the thyristor. Supply for this amplification is derived from the voltage across the thyristor — for when the device has not yet been triggered, this voltage will be high. Care has further to be taken that the thyristors are triggered simultaneously by connecting all the luminescent diodes in series, and supplying them with a sharp current pulse of typical maximum amplitude 500 mA. The Ga-As infra-red emitting diodes are coupled to the photodetectors with lightguides having typically 0,6 to 0,9 dB/m of attenuation. In modern state-of-the-art systems it has been found that this type of system produces about 200 ns longer delays with a 4 m light guide than with an 0,4 m light guide[6]. Seeing that the switching time for this type of thyristor is several microseconds, this is entirely satisfactory. The gate current into the thyristor can reach the required value of 2 A within 1 μs.

The success with which this type of technology has been applied to high voltage supply commutated converters has led to investigation of the application to electronically commutated synchronous machines for 5 to 20 kV, and to static compensator equipment.

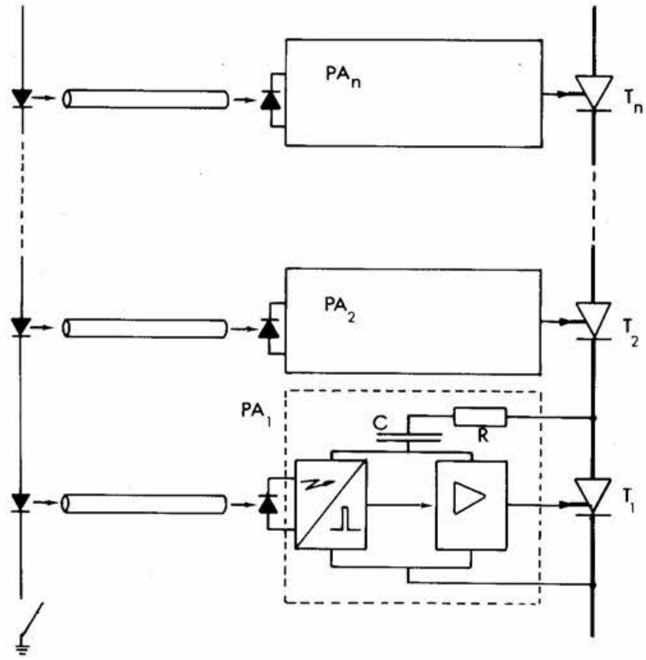


Fig 4 Optical triggering of string of converter thyristors: principle

2 Integrated opto-electronic interfaces in power electronic switches

The success of the discrete interfaces has led to renewed interest in direct light activated switches, chiefly light-activated thyristors (LASCRs) and power phototransistors. In this regard there are some fundamental facts to consider.

Optical powers that can be generated from present day luminescent solid state sources are definitely limited to a few hundred milliwatts in the continuous mode. This is not sufficient to switch power devices of chip area even a few square millimetres directly. When solid state lasers are considered, efficiency in electro-optical conversion and degradation seems to be still troublesome at present[3]. Furthermore, when opto-power-transistors are considered, this optical gating signal may have to be applied continuously — a task for which no solid state component exists as yet. In high speed power switching circuits active charge removal from the power transistor is necessary — something which is not directly possible through an optical gate.

The above considerations have led to the present state where the directly optically controlled power thyristor seems to be the only power device with an integrated optical interface that holds promise for application in the short term.

2.1 Direct optical triggering of power thyristors

The direct optical triggering of power thyristors is at present the subject of considerable research effort by groups working on the development of power thyristors[2, 3, 4]. The first notable progress on applying this concept to large power thyristors with the same dynamic characteristics as electrically triggered units was reported in 1976[9, 10].

Regarding dynamic behaviour of power thyristors,

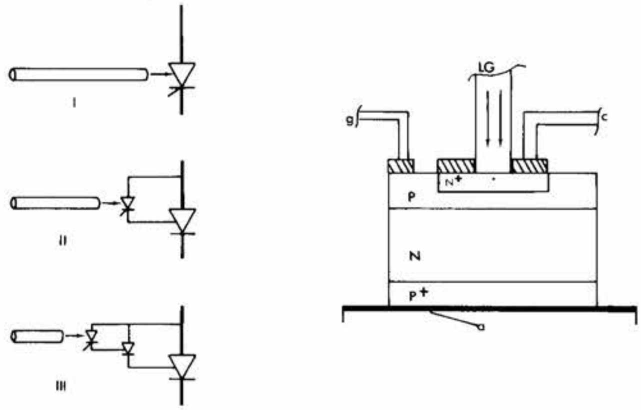


Fig 5 Different possibilities for integrated optical triggering of power thyristors

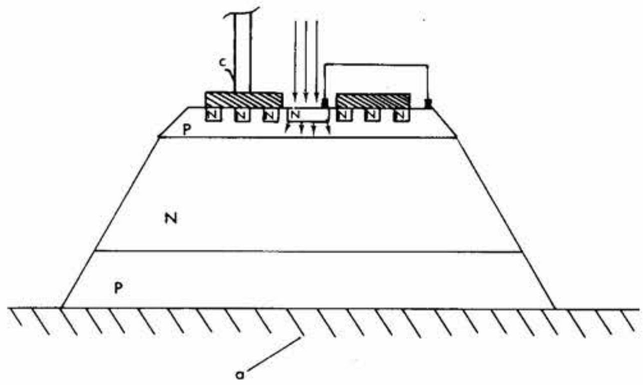


Fig 6 Schematic illustration of optically triggered thyristor with high dV/dt immunity

the trade-off between a high trigger sensitivity (rapid turn on and fast conductive area spreading), allowing the device to operate under conditions of high dI/dt, and immunity to triggering by voltage transients across anode/cathode[1] (dV/dt capability), has been carefully balanced in the spectrum of designs available in conventional devices. This has resulted in the concepts of shorted emitter, field initiated turn-on and amplifying gate being used in appropriate designs. Balancing of these characteristics in opto-thyristors is even more difficult, since the trigger power from an optical source is so low, and necessitates a very high trigger sensitivity.

Fig 5 presents some of the integrated concepts at present being investigated. In I, optical triggering is done directly, as shown in (b). This implies high intensity of radiation (pulsed solid state laser as light source), high trigger sensitivity of the main thyristor (low dV/dt capability) and low loss transmission of light (high quality light guides). This concept has not yet come to practical fruition[3].

The concepts II and III have been reported to give good results[9,10,13] and have subsequently been improved[3,4], since the use of the auxiliary triggering thyristors, integrated into the main structure (Fig 6) allows more freedom for trade-off, while retaining the possibility of using shorted emitter concepts for reasonable dV/dt capability. In these designs, Ga-As: Si LEDs and Ga-As-GaA1As double heterostructure lasers have been particularly investigated as sources. As these devices generate wavelengths from 800 to 950 nm, light penetration from 10 μm to 50 μm can be expected, yielding good carrier generation in the p-base. In all cases light power is in the order of 10 mW to 100 mW, so that the concept of a LASCR triggering a pilot thyristor, all integrated into the main structure has yielded the best results[3,10]. Various schemes have been advanced for improving the characteristics further, amongst which the use of a dV/dt compensating ring[10] and diode[3] appears to hold the most promise. (refer also to Fig 6). These methods all depend on keeping the potential of the n$^+$-emitter at such a level that it does not inject into the p-base during voltage transients. However, when light penetrates through this emitter into the p-base for optical carrier generation, the triggering performance is not impaired.

In summary, comparing the typical parameters given in Table 4, it can be seen that the performance of large, slow opto-triggered thyristors are beginning to match those of conventional units, so that widespread applications of these integrated opto-interfaces may be expected to follow in large supply commutated converting equipment during the next five years.

Table 4 Parameters of directly optically triggered power thyristors. (Typical)

Maximum voltage (V)	Maximum currents (A)	dV/dt (V/μs)	dI/dt (A/μs)	Triggering delay time (μs)	Turn-on Time (μs)	Triggering power (opto-) (mW)	Wavelength (nm)
2 000	1 000	>1 000	>200	6–10	3–5	10–100	800–900

3 Problems and prospects for opto-isolation in power electronics

The numerous possibilities for application of this technology have been pointed out repeatedly in the course of this paper. It has also become clear that there are a few common factors hampering further application in some areas. Whereas considerable effort has been devoted to developing discrete and integrated interfaces in the case of the thyristor switch technology, this has been lacking for power transistor switch technology. The opto-isolators available at present have been developed for small signal logic circuit applications, and are not ideally suited to application in the power transistor switch technology. Faster switching speeds, lower input-output capacitance and more optical output power are required.

3.1 Technical problems and possible developments

Actually the low power output of optical coupling links is one of the most important considerations hampering further development in all fields. This implies sensitive detection circuits at the level of a few tens of milliwatts at the optical output, with the associated capacitive and inductive pick-up problems due to the power equipment operating at kilowatt and megawatt level immediately alongside.

The slow switching speeds of the existing optical links also give rise to a series of problems. Although the speed of the actual optical transmission is high, the delays are mainly caused by the electrical effects at the input and output of the link. As all solid state switches may be seen as charge controlled devices, the delay before operation is dependent on the power level of the incoming signal. Low power signals take much longer to build up the necessary charge distribution in the switch, causing delays.

Slow risetimes tend to give rise to a wide spread of switching instants in series of parallel devices, especially when coupled to low power signals. Series and parallel devices are frequently used in power electronics, due to limited device capabilities for current and voltage. Whereas the present opto-links provide risetimes short enough for slow supply commutated thyristors, their application to fast, force commutated transistor and thyristor power electronics still prove troublesome. With a view to the important potential market for opto-electronic isolators in the professional power electronics market in the lower power ranges (1 kW to 100 kW), development of techniques and special interfaces for these applications may be expected in the near future. To a certain extent examples of this have already been appearing during the past year[14]. Technically the power levels, the switching speeds, delay times, voltage isolation and stray capacitance are being improved.

3.2 Economics of opto-coupling in power converters

From the previous discussion it follows that the economic advantage of applying discrete opto-coupling interfaces instead of pulse-transformers to the triggering of thyristors in large supply commutated converters at high voltage levels (> 20 kV) is without question being accepted. Development of large opto-thyristors with more acceptable dI/dt and dV/dt characteristics[13] will improve this advantage, since the interface is then integrated into the thyristor.

In the low power range (1 kW–100 kW) it stands to reason that opto-coupling has definite economic advantages over magnetic isolation by transformers, since opto-couplers are much better compatible with printed circuit technology than transformers. Costs during large production runs also favour opto-coupling. Unfortunately the technical characteristics of the presently available couplers are still such that their application will be mainly restricted to supply commuted equipment in this range. (refer also to 1.2.1.)

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Field experience with a 140 Mbit/s optical transmission system

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SYNOPSIS

Culminating over a decade of laboratory research into devices and materials for wideband communication over optical fibre waveguides, the decision was made to stage a field trial system in 1977 in the representative environment of an operating authority, the British Post Office. The system was installed in a standard duct system, employed underground repeater housings and used a transmission bit rate as high as the current stage of development allowed. The object of the experiment was to assess installation and operating experience and to evaluate performance using live telephone and television traffic. The results of experiments are reported and comments made on the practical experience gained during installation and in use in a national telecommunications environment.

SINOPSIS

Die hoogtepunt van meer as 'n dekade se laboratoriumnavorsing na toestelle en materiale vir breëbandkommunikasie met optieseveselgolfgeleiers is bereik toe daar in 1977 besluit is om 'n veldtoetsstelsel te loods in die verteenwoordigende omgewing van 'n bedryforganisasie — die Britse poskantoor. Die stelsel is in 'n standaardkanaalstelsel geïnstalleer, het ondergrondse herhaalhulse gebruik en het die hoogste deeltjietransmissietempo gebruik wat die ontwikkelingstadium op daardie tydstip toegelaat het. Die doel van die eksperiment was om installasie- en bedryfsondervinding te beproef en werkverrigting te evalueer met direkte telefoon- en televisieverkeer. Die uitslag van die eksperiment word bekend gemaak en die praktiese ondervinding wat tydens installering en in gebruik in 'n nasionale telekommunikasieverband opgedoen is, word bespreek.

1 Introduction

In recent years momentum has been gathering throughout the world on both research and development in the field of optical fibre communications. By 1975 much had been written on the performance in the laboratory of most of the constituent parts of a practical system, and some laboratory based experiments had been described; however there was very little experience of optical systems applied to realistically harsh environments. Consequently a decision was made to launch work on a system which could be operated in the environment of a typical operating authority. Clearly the correct choice of system to demonstrate the viability of a new technology is complex, but, briefly, the decision was made to develop a digital system as this was likely to be the most compatible with the operating environment and the technology. A high bit rate was chosen on the basis that this would be more likely to expose any unexpected problems than a lower one.

This paper sets out to describe briefly the system objectives of developing and installing the system and the characteristics of it in an operational environment.

1.1 Objective of demonstration system

The primary objectives of developing and building a demonstration system may be summarised as follows:

(a) To extend optical system technology.
(b) To demonstrate the viability of optical systems, particularly of high bit rate systems, in a realistic environment.
(c) To demonstrate that optical communication technology has reached the stage of development where it could be installed with relative ease on even a difficult route.
(d) To develop the technology to the point where repeatable performance of the electro-optic modules could be achieved.

A major factor in ensuring that the system achieved its objectives was the choice of system parameters — ensuring that they would appear to be realistic in spite of this fast moving technology, but at the same time being achievable. It is essential to realise that at the beginning of 1975 when the parameters were selected many of the targets set had not even been achieved in the laboratory, and certainly not on a repeatable basis. The main parameters are summarised in Table 1.

2 System description

The 9 km system shown in Fig 1 consists of three repeater sections, each approximately 3 km in length. At each terminal there is a full range of digital multiplex equipment conforming to CCITT standards. In addition there are a number of standard units including power supply units, 50 mA power feed units for the dependent repeaters and engineering order wire equipment. The engineering order wire is transmitted over the copper conductors within the optical fibre cable; dc to dc converters at the dependent repeaters are necessary to take account of both the laser bias current of typically 180 mA and the 400 V or so required for the avalanche photodiode bias.

In the line terminal, of which Fig 2 is a block schematic diagram, the coded mark inversion interface code is converted to binary plus clock and this is then scrambled in a 15 stage scrambler.[1] A parity bit is then inserted after every 17 information bits. The in-

TABLE 1 — Major Parameters for the Field Demonstration System

Information transmission rate:	139,264 Mbit/s
Line transmission rate:	147,456 Mbauds
Line code:	Scrambled binary plus 1 parity bit after every 17 bits.
Optical transmitter:	CW double heterojunction stripe geometry GaAlAs laser (STL) using closed loop baek face monitoring.
Optical receiver:	Silicon avalanche photodiode, constant current biased, followed by bipolar transimpedance amplifier.
Terminal equipment:	Full range of digital multiplex equipment to CCITT standards, from voice channels to 140 Mbit/s. Also includes standard 50 mA power feed circuits, engineering order wire and alarms connected to station alarms.
Repeaters:	Two intermediate regenerative 2-way repeaters power-fed via copper conductors in the optical cable. Power consumption of 1-way repeater < 4 W.
Cable:	4 fibre (2 working, 1 spare and 1 filler), 4 copper conductors (0,5 mm dia), stranded steel strength member, polyethylene sheath. 7 mm overall diameter.

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† Standard Telephones & Cables Ltd, Basildon, Essex, England

serted parity bit facilitates in-traffic error monitoring at the repeaters. In the receiver side of the line terminal the reverse processes of parity bit removal, descrambling and reconverting the binary to the CMI interface code is performed. Identical repeaters are used at the terminals and at the dependent repeaters.

The repeater shown in Fig 3 consists of an avalanche photodiode driving a bipolar transimpedance amplifier. The photodiode is constant current biased[3] over a wide range of optical input levels to provide temperature stabilisation and a range of AGC. There is a following amplifier which in turn is followed by an AGC amplifier. LC resonant circuits are used for timing extraction. The optical output from the laser at constant drive current is a function of aging and temperature. To stabilise the output against these changes two different approaches have been adopted. In the first a constant amplitude modulation current (Im) is added to a bias current which is adjusted by means of a feedback circuit to maintain a constant mean output power[3]. A monitor signal is obtained by detecing the optical power from the back of the laser.

The second method of controlling the output of the laser is capable of compensating for changes in slope efficiency, should this prove to be necessary, and involves the independent control of the levels of the 'O's and '1's. This is achieved by a sampling technique[3], the time constants of which are related to the characteristics of the line code.

In both cases the 'O' level is adjusted to be just below threshold but not sufficiently below to cause turn-on delay and return-to-zero modulation is employed.

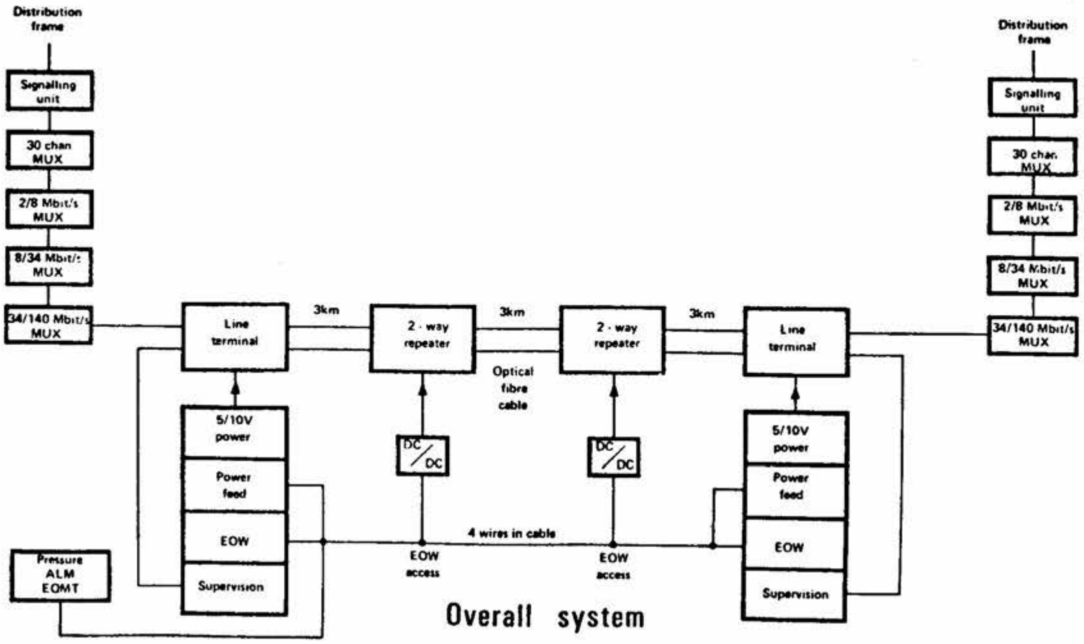

Fig 1 Block diagram of 140 Mbit/s Field Demonstration System

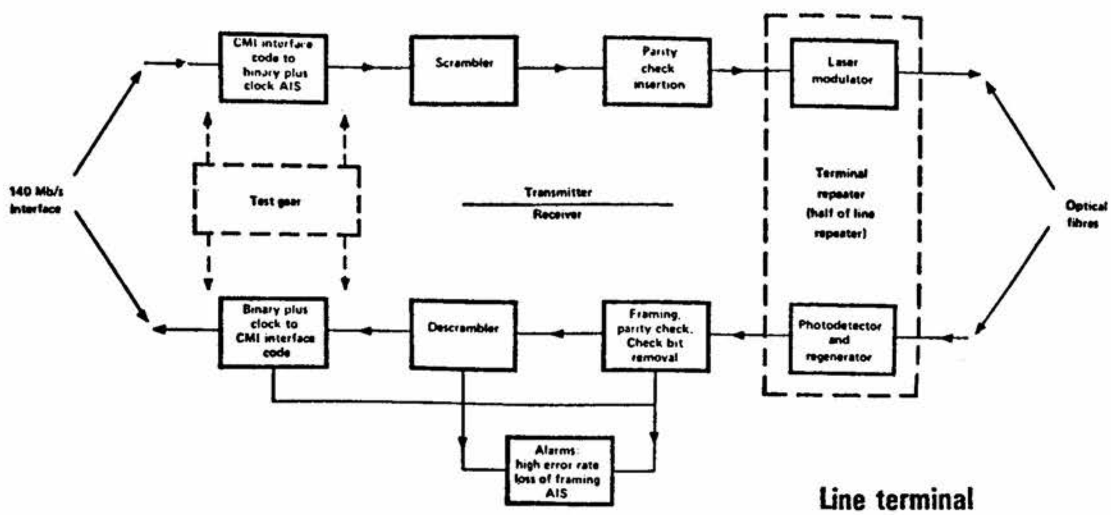

Fig 2 Block diagram of line terminal

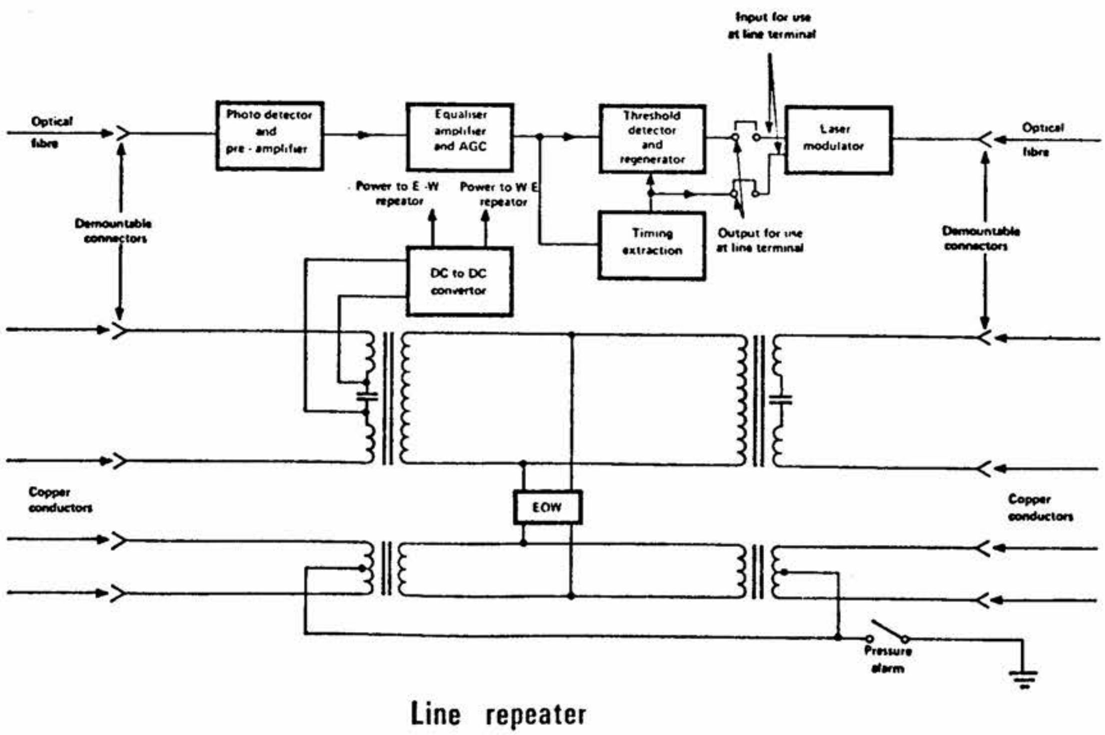

Fig 3 Block diagram of 140 Mbit/s line repeater

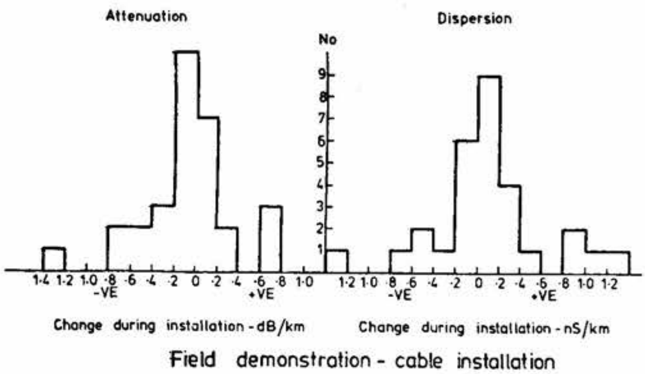

Fig 4 Change of fibre parameters during installation

3 Optical fibre cable

It is essential that the practical cable construction does not significantly degrade the optical properties of the fibre either during manufacture or during service life. In addition, the cable and construction should provide the fibre with some protection against mechanical damage, and should provide it with sufficient reinforcing to prevent breakage of degradation of the optical properties during installation.

The cable design adopted for this field demonstration was a tight construction with a helical lay, and it more than adequately met the objectives mentioned above.

Four fibres and four copper conductors are laid helically around a stranded steel strength member. In the case of this demonstration system there are two working fibres, 1 spare fibre and 1 filler. The fibres have 100 μm outside diameter with 30 μm core. The overall diameter of the packaged fibre is 1 mm and the overall diameter of the completed cable is 7 mm.

Cables were installed by an STC installation team using an instrumented winch; lengths in excess of 1 km were installed using a single pull, and pulling tensions of typically 350 N were required. A single peak tension of 800 N which operated the automatic cut out, was caused by the swivel catching on the duct edge. No fibre breakages were experienced during manufacture of the cable or during installation, nor have any been experienced since.

Changes in optical performance during installation were on average very small; an average decrease in attenuation of approximately 0,1 dB/km and an increase in dispersion of less than 0,1 ns/km, and, as can be seen from the histogram of Fig 4, the spread of results was well confined.

Splicing was carried out in manholes and footway boxes using a collapsed sleeve technique[4] for which a special jig was designed to minimise the degree of skill required. This jig was enclosed in a transparent cover to protect the splices from gross contamination. Only standard procedures were followed for the preparation of the manholes. The average attenuation of the splices of this 30 μm core fibre was less than 0,5 dB per splice.

The attenuation of a cable installed in the demonstration route in permanently wet ducts has been closely monitored for approximately one year. The three curves of Fig 5 represent the performance of the three working fibres within the cable. The first measurement was made a few days after installation, and the value of the ordinate at this point represents the change in attenuation per kilometre caused by the processes in going from primary coated fibre to installed cable. As can be seen from the curves, there is a definite tendency for the attenuation to reduce to-

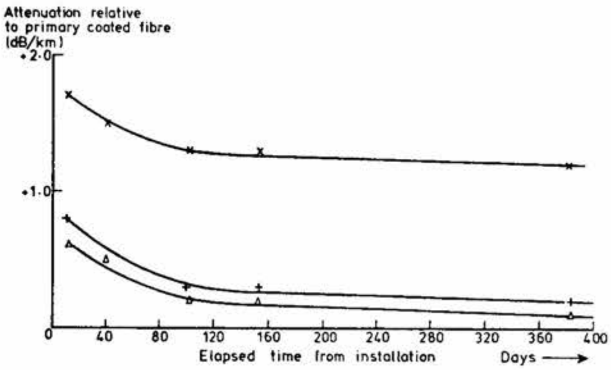

Fig 5 Field demonstration cable attenuation relative to primary coated fibre

wards the value for the primary coated fibre. These results give a high degree of confidence for the future, as fibres within installed cables, having no water barrier, show no sign of degradation in optical performance in more than one year.

4 System performance

4.1 Measured performance

In Table 2 the power budget as planned in 1975 is compared with the performance achieved when the system was installed in 1977. Throughout the period since installation a pseudo-random bit stream has been transmitted and the error rate has been monitored. Typical results of the performance measured over the 9 km route (2 intermediate repeaters) are shown in Fig 6, i.e. an average error rate of $2{,}2 \times 10^{-12}$. The large overall system margin of 24 dB shown in Table 2 has enabled one repeater to be by-passed resulting in a repeater spacing of greater than 6,2 km and no significant change in error rate. The measured jitter of a single repeater is 2° RMS. This performance is well within that which is required by National Administrations for coaxial line systems of equivalent bit rate.

On 6th October 1978, the system was switched over to transmitting British Post Office commercial traffic on an experimental basis.

4.2 Practical experience

When first installed the error rate was variable and this was attributed to two sources: Firstly to noise generated by a Zener diode being injected into the preamplifier and, secondly, to the timing extraction circuit. Circuit modifications have been introduced in both ar-

TABLE 2 — 140 Mb/s System — Planned Power Budget 1975 and achieved 1977

	Planned 1975	Achieved 1977
Power launched into fibre	−3,0 dBm	−3 dBm
Connector losses (2 at 1 dB)	−2,0 dB	−2 dB
Jointing losses (7 at 1,0 dB)	−7,0 dB	−2 dB
Cable losses (8 dB/km)	−24,0 dB	−15 dB
Dispersion penalty (7 ns/3 km dispersion)	−5,0 dB	~−3 dB
Required receiver sensitivity	−41,0 dBm	−25,0 dBm
Achievable receiver sensitivity	−45,0 dBm	−49,0 dBm
Overall system margin	4,0 dB	24,0 dB

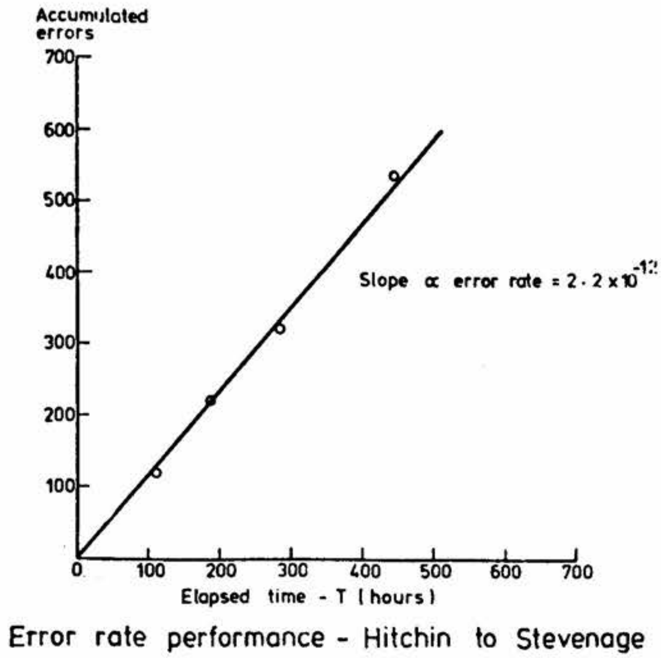

Fig 6 Plot of cumulative line errors for the 9 km system

eas resulting in measured error rates in the laboratory of significantly less than 10^{-12}, but this measurement was limited by mains transients.

During the period of the equipment installation and shortly thereafter when measurements and adjustments were being made, necessitating the frequent disturbance of the optical connectors, two sustained damage of the fibre end. This damage was caused by grit blown into the connectors by passing lorries, but by taking additional precautions it has been possible to prevent a recurrence of the problem. With the exception of the failure of one power supply unit during the first few weeks, no other problems have been experienced.

To gain detailed information about the long term performance of the system, data logging equipment has been installed at the terminals and both the intermediate repeaters. This is commercial equipment capable of accepting thirty channels of analogue data, which is then recorded on magnetic cassettes.

The following parameters will be monitored simultaneously: errors, laser bias current, optical output power, received optical power, cable temperature, equipment temperature, as well as the repeater power lines. All the parameters require analogue inputs, with the exception of the accumulated errors for which a D to A converter is provided.

5 Television transmission tests

It is generally acknowledged that the most exacting signal for a digital transmission system is one that is highly structured, for example television.

In co-operation with the BBC transmission tests of digitised television signals were carried out over the Hitchin/Stevenage link[5]. The equipment was looped at Stevenage to give an 18 km system. On the left-hand side of Fig 7 the BBC digitising and multiplexing equipment is shown. This equipment had previously

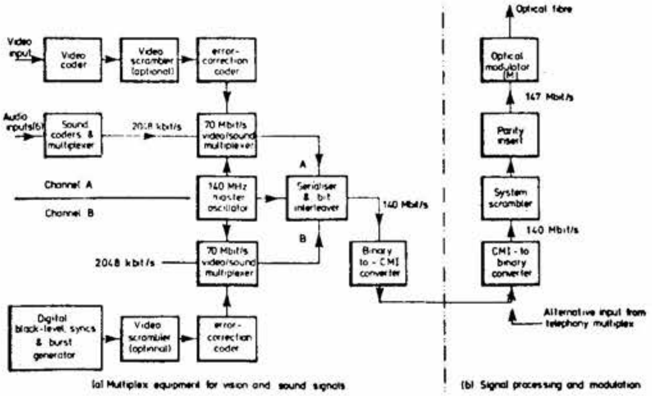

Fig 7 Television transmission tests — sending equipment

been used for field trials at 120 Mbit/s over coaxial line systems and had also been used for tests at 60 Mbit/s through the Indian Ocean Intelsat 4 satellite[6]. Modifications to the equipment have been made to provide operation at 140 Mbit/s.

The equipment consisted of two identical channels (A & B), each channel having the capability of accepting one video channel and six high quality sound channels. The right hand side of Fig 7 represents the sending end of the optical system terminal equipment.

Tests were carried out using an off-air signal from a high quality receiver while the video signal for the other channel was derived from suitable pattern generators. The two channels were multiplexed together with sound channels to give a 140 Mbit/s data stream.

The quality of transmission was determined both by qualitative assessment of the picture and by change in error rate. There were two methods of detecting errors; one by using the built-in system error detectors, and the other by counting the errors corrected by the Wyner-Ash error corrector in the vision channel A. Errors were recorded for combinations of the following variables:

(a) two different configurations of the system scrambler.
(b) video information on channel A, e.g. 100 per cent chequerboard; sync, colour burst, and black level; horizontal grey scale. Channel B always transmitted digitally generated sync black level and colour burst.
(c) coding schemes employed on channel A, e.g. d.p.c.m., p.c.m., h.d.p.c.m.
(d) the four possibilities of scrambling or not scrambling the A and B video channels.

A slight increase in the system error rate was observed when television pictures or television test signals were being carried. This was well within the correction range of the video error correctors and error free pictures were obtained; pattern dependence is not considered a problem. There appeared to be no correlation between error rate and video scrambler combinations.

Throughout the tests subjective assessments of picture were made. For all configurations and source material used there was no detectable degradation introduced by the transmission system.

These results give added confidence that the use of scramblers for a line code for such a system is viable, but additional video scramblers may be desirable for the transmission of highly structured signals.

6 Conclusions

In conclusion, 17 months of operation of a 140 Mbit/s optical system has demonstrated that high bit rate systems can now be built for, and installed in, a realistic environment. Further, suitable circuits can be built to stabilise the performance of the temperature sensitive devices, the laser and the avalanche photodiode, and thus provide long term unattended operation and avoid the necessity for temperature compensation or manual adjustment. Satisfactory error rate performance has also been demonstrated.

In addition it has also been demonstrated that an optical system using scrambled binary for a line code, generated by a 15 stage scrambler, is satisfactory even for a highly structured signal such as television.

It can consequently be concluded that high bit rate optical systems have reached the stage of development where they can be engineered and installed for service use by Administrations with a high degree of confidence.

The authors would like to express their appreciation to both the British Post Office and the British Broadcasting Corporation for their willing co-operation in the tests which have been carried out. In addition they would like to acknowledge the contributions to the work described of a very large number of their colleagues, too numerous to name, who have contributed to the design of the system and who have carefully measured many of the results described.

The authors would also like to thank the management of Standard Telecommunication Laboratories Limited and Standard Telephones & Cables for permission to publish this paper.

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IEC is stepping up work for the medical world†

When the IEC Committee for standards covering electrical equipment in medical practice (Technical Committee No. 62) held its first meeting in 1968, the acting Chairman of TC 62, Professor F Wachsmann, stated that 'radiation protection can be better achieved by one gram of human brains than by a kilogram of lead'.

This statement signalled the future direction of TC 62 in preparing standards for radiation equipment used in medical practice. Through the work of medical experts from all corners of the world representing the views of manufacturers, the medical professions, hospital authorities and other interested parties, thirteen standards covering radiation aspects have been issued and have become widely used in the medical world.

But the work of TC 62 has not only dealt with radiation — it has been expanded to cover the total needs of medical electrical equipment. Some 20 standards have been issued to date including Publication 601–1, the comprehensive general safety standard that applies to all types of medical electrical equipment. Work in hand covers some 40 other medical electrical standards.

In a soon-to-be-published article in the journal 'Middle East Health', Mr Gerrit Gaikhorst, Secretary of IEC Sub-Committee 62A: Common Aspects, expounds the work of his Committee for medical equipment for the patient, operator and equipment, and on the safe application of equipment. The IEC Bulletin presents these extracts from Mr Gaikhorst's article.

On general aspects

At present, medical electrical equipment is extensively used in medical practice in order to assist medical staff in the diagnostic and therapeutic fields. The growing world-wide demand for better health care greatly expands the role of medical electrical equipment in health services.

The seriousness of the consequences that may arise from the use of defective equipment makes it incumbent upon both manufacturers and users of medical equipment to ensure that high quality equipment is properly made and installed. In addition, correct maintenance is necessary for their safe, effective and reliable operation.

The direct interface between patient and equipment has brought new emphasis on the need for maintenance programmes. Medical electrical equipment obviously has a particular relation to the patient, the operator and the surroundings. Some examples:

- the inability of patient or operator to detect the presence of certain potential hazards, such as ionizing of high-frequency radiation;
- absence of normal reactions of the patient who may be ill, unconscious, anaesthetized, immobilized etc.;
- absence of normal protection to currents provided by the normal skin if this is penetrated or treated to obtain a low skin-resistance;
- support or replacement of vital body functions may depend on the reliability of equipment;
- the simultaneous connection to the patient of more than one piece of mains-operated equipment;
- combination of high-power equipment and sensitive low-signal equipment often in *ad hoc* combinations;
- combination of electrical circuits directly to the human body, either through contacts to the skin, and/or through the insertion of probes into internal organs;
- environmental conditions, particularly in operating theatres, may present a combination of humidity, moisture and/or fire or explosion hazards caused by oxygen or nitrous oxide, anaesthetic media and cleansing agents.

In general, it is difficult for medical staff to judge the safety and performance of equipment. Equipment is manufactured to such a safety level that any risk during application is avoided and at the same time a commercially acceptable product is produced. This presumes that the manufacturer has built in certain product safety precautions.

If general guidance is not available, the manufacturer will follow his own experience which may conflict with that of the user. In order to avoid such a situation, national standards set certain safety levels. A standard is a set of rules produced by a consensus of manufacturers, users and scientific specialists. This consensus evolves an acceptable safety level for all parties which means that safety precautions are prescribed to minimize the risk of a safety hazard. However, if such a national standard is based only on a national basis, it may differ from country to country.

Medical electrical equipment can only be produced in relatively large quantities due to the increasing costs of research, development and marketing. The manufacturer, to overcome these problems, needs access to a large market — the international market. But if, in doing this, countries have different standards, the manufacturer needs different production lines which increase production costs.

The only solution is an international standard to which national standards can comply or which can be implemented in the particular country.

On safety systems

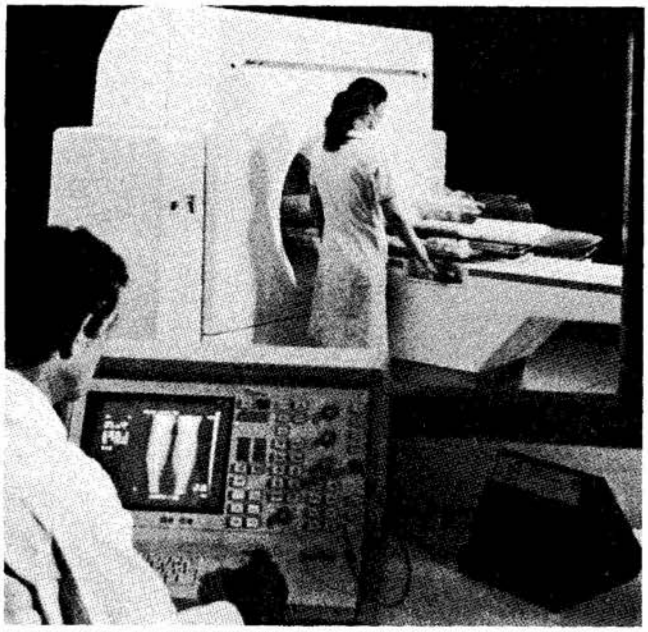
Safety of medical electrical equipment described in IEC Publication 513, is part of the total safety consideration in international medical standards: safety of equipment, safety of the installation in medically used

† With acknowledgement to the IEC Bulletin

rooms and safety of application. Safety of equipment is generally required for normal use and normal conditions and for a number of defined single-fault conditions. Safety is a compromise between the acceptance of a risk and the costs involved to avoid safety hazards.

The total safety of equipment may consist of:

- precautions incorporated in the equipment (unconditional safety);
- additional protective precautions, such as the use of shields or protective clothing (conditional safety);
- restrictions in the instructions for use concerning transport, mounting and/or positioning, connection taking into consideration the equipment's operation and the position of the operator and his assistants in relation to the equipment during use (descriptive safety).



Medical electrical equipment is extensively used in medical practice in order to assist medical staff in the diagnostic and therapeutic fields.

Generally, safety precautions may be realised by sound engineering practice (which includes knowledge of methods of production and environmental conditions during manufacture, transport, storage and use), and by the application of secondary and/or protective devices of a mechanical or electrical nature.

The most important part of medical electrical philosophy is to protect the patient, operator and surroundings as far as possible without restricting the normal function of the equipment. While realizing this, solutions that give adequate protection are preferred.

Hence IEC standards for medical equipment contain safety provisions for the electrical installation and for its supply and give guidelines for its safe application.

Soon-to-be-published safety provisions

The safety of equipment during application depends highly on the safety provisions of the installation to which it is connected. In all countries, safety requirements exist for buildings and these requirements are based on the fact that in living quarters, healthy people have no continuous contact with electrical equipment or installation parts. At present, safety provisions for such installations are based on the restriction of a touch voltage of 50 V max. If an unintentional contact is established, the resistance incorporated in the circuit due to, for example, floor covering is such that one is not conscious of its effect.

However, in medically used rooms, in which patients are treated with medical electrical equipment, a continuous contact may be established or the patient may be treated in such a way that his natural protection against currents is by-passed. Electrodes may be connected to the human heart. In such critical areas, it is essential that potential differences should be restricted to 10 mV.

In case the public mains system fails, an emergency power supply will take over the normal supply in order to continue medical treatment.

High-frequency electromagnetic fields may cause interferences and malfunction of equipment. The soon-to-be-published IEC standard for medical installations describes methods to measure the fields and provisions to avoid interferences.

As a minimum requirement, the installation shall be built to the so-called 5-wire system (3-phases, neutral and separate protective earth conductor). Depending on the local regulations and the way equipment is used in the treatment of the patient, a number of well prescribed safety provisions can be built into the electrical installation in addition to the basic requirement, so the hospital can make a selection of safety provisions they regard as optimal in the particular medically used room.

On subjects calling for particular attention by hospital staff

Staff members with medical training must familiarize themselves with the electronic features of electrical equipment. Hospital technical staff who are often involved in judging the safety of the equipment, must acquire a grounding in medical and physical concepts as well as a thorough understanding of the equipment design and construction with a view to ensuring safe application. They must be able to calibrate the equipment or supervise its calibration by others. They must collaborate on short instruction programmes for the medical staff, nursing personnel, or indeed patients.

Technical staff must also be able to discuss with medical staff subjects connected with interference problems arising when combinations of electro-medical equipment are involved.

Matters technical staff should stress when having such discussions include:

- that frayed or damaged power cables and broken plugs or socket-outlets must be replaced;
- supply cables over four metres in length should not be used;
- extension cables should not be used;

- do not use adaptors;
- leakage current testing of equipment (in accordance with standards) should be carried out regularly;
- equipment earthing should be checked regularly with an earth tester, which injects 25 A for 5 s into the equipment's earth circuit;
- the neutral-to-earth loop impedance of all power supply points, socket-outlets and metal in the patient's environment should be checked regularly with a neutral to earth loop impedance tester, which injects 25 A for 5 s into the loop circuit.

On improving the safety of patients

The safety of the patient will be enhanced if the staff attending a patient follow these suggestions:

- avoid the possibility of becoming an electrical connection between lethal electrical equipment in the patient's environment with the patient, by using one hand only;
- avoid touching the patient with one hand and adjusting electrical equipment with the other;
- avoid touching guide wires, transducers and catheters, etc with one hand whilst adjusting equipment or other devices with the other;
- wear rubber gloves when handling catheters whenever possible;
- if catheters must be handled with bare hands in an emergency, the operator should ensure that his hands are dry;
- check equipment regularly for defects. In case of doubt remove the equipment from service and report if defective;
- do not use equipment as a shelf for liquids which may spill and enter the equipment;
- if equipment fails, immediately disconnect it from the power supply and the patient, before attempting any corrective measure.

Finally, it is essential that medical specialists consult a clinical engineer before he puts any equipment into actual use.

Abstracts

Much can be done to minimize medical hazards if the recommendations summarized below are followed:

- good engineering practice should be followed for the installation and maintenance of equipment;
- staff attending a patient should be trained in the safe and correct use of all equipment and should be encouraged to observe the precautions mentioned in the application of equipment;
- when purchasing equipment, with circuits which include electrodes or other applied parts that are intended to come into direct contact with patients during normal use, specify compliance with IEC standards;
- special precautions must be taken with reference to cumulative leakage current in multi-equipment monitoring situations;
- for future installations, the requirements specified in IEC standards for electrical installations should be followed;
- training instructions and preventive maintenance shall be carried out in order to keep the safety level at an optimal condition.

Obituary

Walter Henry Milton was born on 18th January 1899 and died in Johannesburg on 25th April 1981.

He attended the King Edward VII School and obtained a degree in Electrical and Mechanical Engineering in 1920 at the School of Mines and Technology, Johannesburg. After graduating he served his pupilage with Metropolitan-Vickers Electrical Company, Manchester, England. He then returned to South Africa where he was responsible for the erection of the first Class 1E locomotives for the SAR. He joined ESCOM in 1926 and rose from Assistant Contracts Engineer to Chief Commercial Engineer, a post he held until his retirement in 1966.

He joined the Institute as a Student Member in 1917, became a Member of Council in 1935, was elected President in 1947 and was made an Honorary Fellow in 1968. His 64 years of membership of the Institute, his 46 years as a Council Member and 34 years as a Past President are unequalled in our history. He took a particular interest in the Constitution and Rules of the Institute and was regarded as a 'fundi' on the Committee dealing with these.

Besides his career, his work for the Institute and his family interests, he took a great interest in University education and in sport administration. He was the first Chairman of the original Student Section and served as President of Convocation at the University of the Witwatersrand in 1948 and 1949. He served as President of the University cricket club for 32 years and President of the hockey club for 28 years. The University's main sports field for cricket and hockey was renamed the Walter Milton Oval in his honour.

Walter Milton is survived by his wife, his daughter and two grandchildren.

TRIBUTE TO MR W H MILTON BY MR H T ASPINALL AT A LUNCHEON HELD ON 15TH APRIL 1981 FOR MR MILTON ON THE OCCASION OF HIS RETIREMENT FROM COUNCIL

Recently I was in touch with the President and during the conversation reference was made to Walter Milton. Grant Park made an interesting comment. He said that Walter had been a source of inspiration to him when they were colleagues at ESCOM and in later years.

In the preparation of an Historical Index for the Institute I came across a reference to a farewell to Mr W H Milton in 1921 on the occasion of his resignation as Chairman from the Student Section. I think that this step immediately preceded his departure for Manchester to begin his graduate apprenticeship with Metropolitan-Vickers. It is remarkable following a lapse of sixty years there is a second farewell today. Reference to this lengthy period is a reminder that I, too, am beginning to feel old!

During his period of training he met someone who has meant a great deal to him in later life. I am referring to Ada, his charming bride from Cheshire.

On his return to South Africa he continued to take a keen interest in Institute affairs and in 1939 he became a Full Member as it was then termed. Following a period on Council he was elected President in 1947. On the occasion of his induction the outgoing President, Mr Alan Dalton, referred to the new President as possibly one of the best and widely known engineers. And that was over thirty years ago!

His Presidential Address was titled 'The Future of the power supply in South Africa' in which he made valuable suggestions relating to the long-term development of the industry following the then recent war period.

Over the years he has rendered yeoman service on the Membership and the Constitution and By-laws Committees. In regard to the latter he has even been asked to continue assisting the committee following his retirement from the Institute. In 1968 he was honoured by Council in his election as Honorary Fellow.

Apart from his interest in the Institute he participated in Convocation affairs of the University of the Witwatersrand; he was President of Convocation for a number of years. In addition, he took a prominent part in the activities of the Association of Municipal Electricity Undertakings of South Africa over a lengthy period. It was a pleasure to listen to his informative addresses at the various conferences.

Walter Milton has made a considerable contribution through the years to the building-up of the Institute as it is today. I would venture to say that he has a record of outstanding service to the Institute, a record which will remain unsurpassed.

Obituaries

Arthur Robert (Bob) Mullins was born in Komgha in the Eastern Cape on 4th July 1903 and died in Johannesburg on 2nd August 1981.

He was educated at St Andrews College, Grahamstown and was a Rhodes Scholar at Trinity College, Oxford from 1923 to 1926. From 1927 to 1933 he was a College Apprentice with Metropolitan-Vickers Electrical Company, Manchester, England and was a member of the Johannesburg Office staff of that company from 1934 to 1936. He was also a staunch member of the Metropolitan-Vickers Overseas Association.

In 1936 he was appointed Electrical Engineer to the Union Corporation, a position he held until 1940 when he became Acting Consulting Mechanical and Electrical Engineer. He was the Consulting Mechanical and Electrical Engineer of this Mining Group from 1945 until his retirement in 1967.

He joined the Institute in 1937 and became a member of Council in 1943. He was elected President in 1953 and became an Honorary Fellow in 1965. In 1961/1962 he was President of AS & TS and as Senior Vice-President and President he was largely responsible for the alterations to Kelvin House. In this office he had discussions with responsible Ministers and Government officials on matters concerning the engineering profession, in particular, the question of non-white membership of the Constituent Societies.

Mr Mullins was President of the Professional Engineers Joint Council for the year 1964/1965, and as an office bearer of that organisation he was instrumental in ensuring that legislation affecting the engineering profession should take a more acceptable form than might have been the case without his direct concern and interest in the matter. He is survived by his wife, three children and six grandchildren.

Dr T L Wadley, a Member of the Institute since 1954, was born on 9th February 1920 and died at Warner Beach, Natal, on 21st May 1981.

During the Second World War, Dr Wadley served in the Special Signal Services of the SA Corps of Signals and made a major contribution to the design and construction of locally-built radar equipment. In February 1946 he became one of the founder members of the Telecommunications Research Laboratory, which had just been established by the CSIR and which later became the National Institute for Telecommunications Research. This marked the start of a distinguished career in electronic applications.

His first contribution to receive world recognition was the design and development of a new and greatly improved ionosonde — a device used for probing the ionosphere with radio waves. Instruments based on his principles have since been built in many countries and are in use today. Dr Wadley then designed and made the world's first variable frequency crystal-controlled communications receiver. The principle was patented and, although it was initially greeted with scepticism overseas, was later adopted by a large British firm which engineered it to stringent military specifications and put the receiver into quantity production under licence to the CSIR. Wadley's greatest achievement was the successful development, in the fifties, of the 'Tellurometer' system for measuring distance by means of radio waves, which revolutionized surveying throughout the world. His achievement was all the more remarkable because he was in competition with many other organizations which had been striving unsuccessfully to produce similar instruments and had spent vast sums of money in the effort. A company was formed in Cape Town to produce these instruments, which became the first major electronic export from this country.

During his career, Dr Wadley was honoured by many learned bodies including the South African Institute of Electrical Engineers, the Suid-Afrikaanse Akademie vir Wetenskap en Kuns, and the Franklin Institute of the USA. A paper on the electronic principles of the 'Tellurometer', presented to a distinguished audience at the Royal Geographical Society, London, in 1957, was received with great acclaim. In 1960 he was awarded the Gold Medal of the SAIEE, in 1976 the National Award of the Associated Scientific and Technical Societies of South Africa, and in 1976 an honorary doctorate in science by the University of Cape Town.

Proceedings of the seven hundred and thirtieth general meeting

Held in the Auditorium, ESCOM, Megawatt Park, on Thursday, 23rd July 1981 at 18h30.

L H James (Vice-President) was in the Chair and 82 members and visitors were present.

Minutes

The minutes of the general meetings held on 26th May and 25th June 1981 were taken as read and were confirmed.

Candidates elected to membership

The Vice-President announced that in terms of By-Law B1.3,5, Council had elected the undermentioned candidates to membership of the Institute in the following grades:

As Members Gordon Samson Gregson, Christoffel Johannes Wynand Langeveldt

As Graduates James Philip du Toit, Jan Abraham Ferreira, Alan George Lavery, Hilton Allen Lewis, Nicolene Payze, Willem Harmanus Steyn, Pierre van Rhyn.

As Students Danie Botha, Alan Duncan Bowden, David George Bradford, Norman Keith Burgess, Kevin George Dove, Mark Richard Evans, Adriano Manuel Povoa Ferreira, Paul Ivan Johnstone, Jane Margaret MacGregor, Jonathan Ashley Marks, Dirk Adriaan Marshall, Winston Msingizane Ngwenya, Piotr Ogonowski, Michael David Pallett, Gerhardus Roedolf Posthumus, Jan André Raats, Clive Bob Rothenberg, Errol Sacks, Michael Joseph Sonnabend, Michael Steven Speyer, Wilfred Wolfgang Wenzelburger.

Transfers

As Members to Fellows Bruce Farish Carpenter, Sarel Arnoldus Cilliers.

As Graduates to Members Norman George Archibald, Ettienne Cristo Botha, Alfred Max Eugene Schulze.

As Students to Graduates Claudio Enzo Agostinetto, Andrew John Mather, Robert Hong, Hans-Werner Rudolf Matthaei, Thomas Milifi Molamu, Noel William James Northcott, Clive Jacques Poorter, Horst Psotta, Roelof van Ark.

The Vice-President congratulated those members who had been elected or transferred to a higher grade.

General

Nothing had been raised under this item.

Talk

The Vice-President called on Mr A M Brauer, Chairman, Control Section, to introduce the speakers Mr Brauer said:

> It is my pleasure and privilege to welcome you all on behalf of the Measurement, Control and Computation Section of the Institute. As the current Chairman of the Section Committee, I greatly value this opportunity to let you know that the Section Committee has been reconstituted recently. There is a strong determination to revive the activities of the Institute in the area of Control Engineering, Measurement and Computation. Plans of short and long term activities are being formulated right now. Therefore, I would urge you to respond to the questionnaire that is going to be circulated to you very soon. By doing so you would enable the Section Committee to plan and cater better for your interests and needs. Secondly, by letting us know your interests you will stand a better chance to directly influence activities. The field of Automatic Control, Measurement and Computaton enjoyed a progress that can be described as one of the fastest over the last few decades and offers a multitude of topics of interest.

Mr Brauer then introduced Mr H Timme and asked him to present his paper entitled

Power systems unbalance — its cause, effect and measurement

Mr Brauer thanked Mr Timme for his presentation and introduced Mr G J Korvink who presented his paper entitled.

A method for the measurement of sequence component watts and vars

Prof J P Reynders, Messrs H B Norman, E F Raynham and C R Whitburn contributed to the papers and the authors replied to these contributions.

Closure

The Vice-President thanked the speakers and the contributors and closed the meeting at 20h05.

Branch Notes

CAPE WESTERN CENTRE

Security of sites

The 294th general meeting was held in conjunction with the Cape Western Branch of the S A Institution of Mechanical Engineers at the Athenaeum on 9th July 1981 and was attended by 51 persons.

A lecture entitled 'Protective security of industrial sites' was presented by Mr P Smits, an engineer who has made a study of sabotage methods and systems for protection of property etc.

Mr Smits' informative lecture was highly supported by slides, followed by an interesting film on sabotage and incendiarism. Methods and systems which have been developed for protection against unauthorised intrusion, and security against damage from such facets as release of waste products, accidents, fire and natural disasters were outlined.

The need for careful pre-planning was also emphasised.

The Vote of Thanks was proposed by Mr P Evans-Watt, Chairman of the S A Institution of Mechanical Engineers, Cape Western Branch, followed by an interesting discussion.

In closing the meeting the acting Chairman for the meeting, Mr C Bryant also thanked Mr Smits.

Student papers

The 295th general meeting held at Stellenbosch University on 13th August 1981 was attended by 39 persons. This was the annual students papers meeting and the following papers were presented:

Selective harmonic reduction in current-fed inverters by Mr R Mason of the University of Cape Town.

'n Mikroprosessor-gebaseerde statistiese ontleder van kragstelsel harmonieke deur Mnr L P du Toit, Universiteit van Stellenbosch.

Mr Mason analysed research he had carried out on inverters and with the aid of screened illustrations explained the circuitry and principle of operation of an inverter system which involves the application of pulse-width modulation techniques. The sequence of firing of the thyristors was also explained. Among the applications mentioned is the control of induction motors, the aim being constant torque and slip.

Mr du Toit described the work that he had done in connection with the study of harmonics and with the aid of screened illustrations the circuitry and system developed for this analytical work was explained.

The system uses a microprocessor and a suitable interface, the theory of operation being based to a large extent on a discrete Fourier transform.

Mr Siepker of Stellenbosch proposed the Vote of Thanks to Mr Mason and Dr Case of Cape Town proposed the Vote of Thanks to Mr du Toit, which was followed by a discussion on both papers.

The Chairman, Mr J Carlson also thanked the two speakers and the University for permitting the meeting to be held there, and for the refreshments.

LETTERS TO THE EDITOR

Letters on matters of general interest to the Profession have, from time to time, been published in the *Transactions*, and these have proved to be useful as a means for the exchange of opinions.

Only letters signed by the writer will be considered for publication. Should the writer prefer it, he may request that the letter be published under a nom de plume.

Letters should be addressed to:

The Secretaries,
The South African Institute of Electrical Engineers,
PO Box 61019,
Marshalltown 2107.

NEWS ITEMS

Advanced range of percussion drills

The largest and most advanced range of percussion drills that will revolutionise the power tool industry in South Africa, has been introduced by AEG. Eight completely new industrial rated machines offer standards never before reached by any supplier in the world, it is claimed.

The flagship of the new generation drills is the Powermatic SB 2E-901, claimed by the company to be the most sophisticated electronic percussion drill available. It has unparalleled features and almost thinks for itself. It is capable of keeping selected speed constant and has fully automatic power waiting in reserve to be used should an obstruction occur. This applies in every speed range. From a gentle start to percussion drilling means that no centre punching is required and it is quieter due to the reduction of the no load speed.

The new unit has a completely insulated metal gearbox and gives protection through a thick layer of polyester so even if the user should drill through a power cable he would come to no harm. The inner metal gearbox ensures absolute precision positioning of the gears and bearings.

A safety clutch prevents accidents when the drill bit catches, meaning that the machine will not be wrenched out of the operator's hands. For permanent safety the release timing never alters. The newly developed synchronised gears make it possible to change speeds even when the motor is running, therefore avoiding unnecessary time being wasted. It has a powerful 900 W motor, making this machine, it is believed, the most powerful available as 540 W output is achieved.

The service-minded electronic module technology incorporated in the unit means that all the electronic control components are mounted together on a single circuit board which means a simple exchange should repair be necessary, thus saving both time and energy considerably.

A powerful alternative choice is the pneumatic SB2E-757, identical to the SB2E-901, the only difference being the power rating of 750 W and of course the price.

In order to give the South African power tool user, industrial or do-it-yourselfer, a wide choice of motor powers and a variety of features, AEG offers four additional electronic percussion drills. These are the SB2E-651 with 650 W input and the SB2E-500 with a 500 W motor. The SB2E-451 RL and SB E-401 RL offer the benefit of anti-clockwise drive and can be used for a variety of functions such as a screwdriver or a lapper.

Completing the new generation of AEG percussion drills are the SB2-501 with the unique fully insulated gearbox and synchronised gears and the SB2-401 equipped with a powerful 400 W motor offering amazing value for money. Both drives offer two speed choices. Prices for the new generation range from R89 to R299 and are available at selected AEG stockists throughout the country.

According to Mr Jan Scholten, marketing manager of AEG Power Tools Division, 'Never before in the power tool industry has such an impressive and advanced range of percussion drilling machines been released. The Powermatics are far ahead of any competition products and the impact will soon be felt throughout the power tool trade as has happened in Europe.'

AEG Telefunken (Pty) Ltd,
P O Box 10264,
Johannesburg 2000.

Variable speed drives thrust

South Africa's newest name in power electronics — Ampower — was launched at a gala function in Johannesburg recently. The amalgamation of Saftronics (Pty) Ltd and the variable speed drive division of Stone Stamcor (formerly Stone Platt Electrical) will give South African industry considerable thrust in the field of variable speed drives.

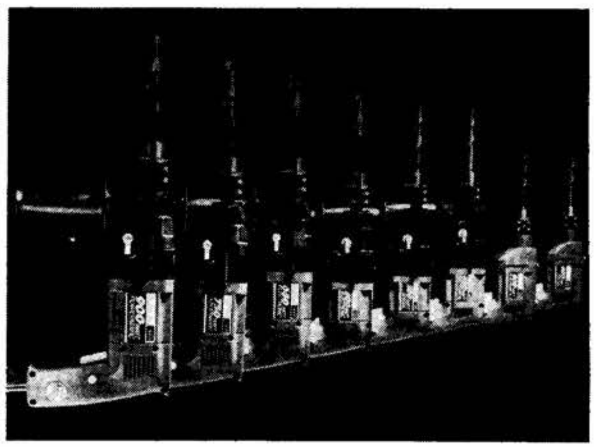
Ampower's managing director, Mr Dick Sorensen, said the amalgamation of the two top companies would create a giant and a driving force on which the trade could depend.

All facets of the two companies' operations have been combined, including the sales teams. Joint product ranges will provide for every requirement in the variable speed drive field — and the development of new products will have behind it the best brains in the business.

'We've retained our strengths and streamlined on weaknesses to create a company that will be bigger, better and stronger in every way. The industry will reap the benefits of this pooling of talent in product quality, in delivery times, after sales service and our broadened market base,' said Mr. Sorensen.

With the kind of track record both companies have already established, the combination which has created Ampower will surely be 'the driving force you can reckon on,' he said.

The range of specialist equipment Ampower offers is solid. Single and three-phase variable speed dc thyristor controllers — with optional features to enhance



AEG's new powermatic range of percussion drills

versatility — dc motors and tacho generators, including names such as Reliance, Bull Mawdsley, Honeywell, Indar, Baldor, H J Scott, Red Lion, Radio Energy and E W Hof — ac motor speed controllers, high power rectifiers and corona discharge treaters.

The list continues with thyristor controllers for furnance heating, for wire annealing, crane controllers and digital equipment. And Ampower promises an ever increasingly impressive range to keep pace with development and demand.

Ampower,
P O Box 43027,
Industria 2042.
Tel 27-4152.

Highmast lighting for interchanges

Highmast lighting for complex interchanges had its origin in Germany in the early 1960s with the Heerdter Dri-Eck installation near Düsseldorf. The first installation in Britain was made in Bristol in 1964 and South Africa was not long in following suit. Installations were made in Port Elizabeth during the early part of 1968. Further installations followed in Cape Town, Johannesburg and Durban.

The theory behind the scheme of highmast lighting is simple and logical. Complex interchanges illuminated by conventional techniques confront the approaching driver with a confusing array of bulbs and lights. By mounting high powered luminaires with a good 'cut-off' light distribution pattern at 30 m or higher, the whole area is clearly delineated so that the driver can see the lay-out of roads and position of other vehicles or obstructions without difficulty.

Dorbyl Structural Engineering (Bowmast),
P O Box 68,
Germiston 1400.

High-quality mobile radio

The Century II mobile radio is a rugged, high-quality set, ideal for most business and industrial operations. And most business or industrial budgets. A radio that is also tailor-made for anyone who wants to move up to the management control only FM two-way mobile radios can provide.

Nowhere else can you get so many no-compromise, quality features and options at such an affordable price, it is claimed.

Crisp, clear, understandable audio from a front-facing built-in speaker plus up to 25 W of RF output in high-band and 20 W in UHF.

- An all-metal case plus printed circuit boards instead of a jumble of problem-causing wires.
- Stabilized power output.
- A fully transistorized, plug-in microphone, plus an optional power supply that converts the radio to base station use.

Any way you look at it, the Century II is the sensibly priced, quality business radio that will stay on the job, doing its job. The radio that's just right for so many businesses today.

Multisource (Pty) Ltd.,
P O Box 39663,
Bramley 2018.

Highmast lighting at the Geldenhuys interchange near Johannesburg supplied and installed by Bowmast, a division of Dorbyl Structural Engineering (Pty) Ltd. The high powered luminaires clearly illuminate the entire interchange so that drivers can see the layout of the roads and position of other vehicles without difficulty.