ELECTRONICS AND TELEVISION & SHORT-WAVE WORLD

NOVEMBER, 1940

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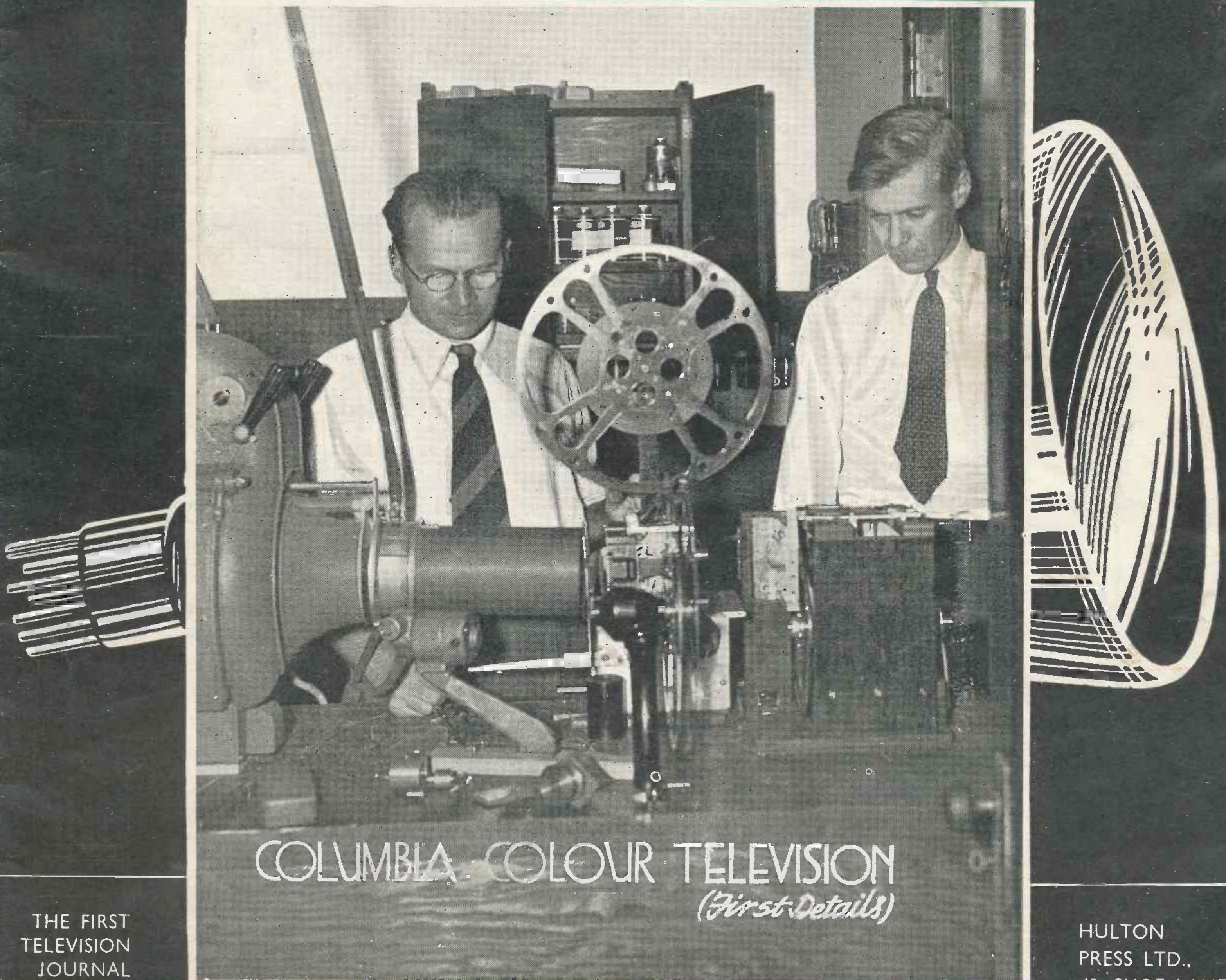

THE FIRST TELEVISION JOURNAL IN THE WORLD

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ELECTRONICS AND TELEVISION
& SHORT-WAVE WORLD

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CURRENT ELECTRONIC LITERATURE

Breakdown Potentials of Gases under Alternating Voltages. (Fox and McCoy.) Breakdown potentials for hydrogen, nitrogen, helium and argon of commercial purity at frequencies up to one million cycles per second were investigated, using a discharge tube with spherical electrodes. Five gap distances were employed, ranging from 10 mm. to 50 mm. Graphs are plotted showing breakdown potential against gas pressure at the various gap distances, and breakdown potential against frequency at various gas pressures with the gap distance fixed. The slope of the log pressure against log distance curve for a given breakdown potential was found to be independent of frequency and also of the gas for small gap distances.
—*Journal of Applied Physics, Sept.*, 1940.

Lubrication in Vacuum by Vaporised Thin Metallic Films. (Atlee, Wilson and Filmer.) The authors describe a method of lubricating the bearings of rotating anodes of X-ray tubes by vaporising a thin film of low vapour pressure material, such as pure barium metal, on to the bearings in the final vacuum. Results are presented of tests with many different metals as the vaporising films and combination films, as well as different base materials. Experimental evidence indicates that the lubricating film is a liquid alloy of barium and metals such as cobalt, chromium, or aluminium. The authors suggest that these results might be applied to other cases of bearings operating in vacuum, or to rotating devices where organic lubricants are undesirable. —*Journal of Applied Physics*, Sept., 1940.

Permanent Magnets. (Kayser.) After outlining the two major developments in magnet steels since 1918, *viz.*, the introduction of cobalt steels and nickel-iron-aluminium alloys, the author gives some particulars of the latest process, in which certain magnetic alloys containing cobalt, nickel, aluminium and iron are cooled from a high temperature heat treatment in a magnetic field of approximately 3,000 C.G.S. units. This treatment is claimed to yield remanences in the vicinity of 12,000 coercive forces in the vicinity of 600, and (BH) max lying between 4,500,000 and 5,000,000. The higher remanence and (BH) max of the new magnets is expected to enable them to replace small electro-magnets in many applications.—*Engineer*, Sept. 20, 1940.

The Nature of the Welding Arc. (Alov.) The author presents a study of the forces operative in the welding arc and factors affecting the transference of metal from the electrode to the surface being welded. In the first part of the paper the author gives a theoretical and experimental investigation of the electromagnetic axial force set-up in the welding arc due to its conical shape, the author's experiments showing, it is stated, that the anode spot is larger than the cathode spot. In the second part of the paper the effects of gravity and surface tension of the molten metal on the transference of metal are discussed, experiments being carried out on bare or thinly coated electrodes. Mention is also made of the use of special coatings for electrodes, to control the surface tension, and hence, the transference of metal. —*Welding Industry*, Sept., 1940.

Crack Detection by Electromagnetic Methods. (Seymour.) The general principles of electromagnetic crack detection are outlined and consideration given to the three common methods—the needle, magnetic powder and magnetic fluid methods. The importance of obtaining the correct degree of magnetisation is emphasised. Other problems noted are: the use of detecting inks or coloured magnetic fluid, use of special windings to avoid inductive current discharge, and methods of demagnetisation of tested articles. —*Electrical Engineer*, Sept., 27, 1940.

Abstracts by Research Department, Metropolitan Vickers Electrical Company Ltd.

PRINCIPAL CONTENTS NOVEMBER, 1940

Contributions will be promptly considered: they should be accompanied by a stamped addressed envelope for return in case of non-acceptance.

Manufacturers are invited to send details of new productions for review.

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News and Views

IT is difficult to define the precise difference between an idea and an invention. Under normal conditions an invention is a development of an idea and generally entails a vast amount of work and money before it can be brought to the stage at which it has commercial possibilities.

The present need is for ideas, developed or otherwise, that will help to win the war and the fact that there is tremendous scope in the electronic field needs no stressing. Practically every reader of this journal has considerable technical ability and knowledge and we suggest, therefore, that each one should turn his attention to the many possibilities that exist.

A Government scientific advisory committee has now been set up and its principal duties will be to advise the Government on the selection of indivduals for special scientific duties, and to bring to official notice any new war inventions or technical developments.

The members of the committee are Sir William Bragg, President of the Royal Society; Dr. E. V. Appleton, secretary of the Department of Scientific and Industrial Research; Sir Edward Mellanby, secretary of the Medical Research Council; Sir Edwin Butler, secretary of the Agricultural Research Council; Professor A. V. Hill, physical secretary of the Royal Society; and Professor E. C. Egerton, biological secretary of the Royal Society, with Lord Hankey as Chairman.

Under present conditions it is not essential to fully develop an idea—if it is of practical value that will be done by experts. Every idea or invention is given careful consideration and a report is made of its probable usefulness or otherwise by the specialist branches concerned.

The departments which deal with war inventions in the Admiralty, War Office and Air Ministry come under four categories: inventions concerning the Admiralty should be submitted to "The Director of Scientific Research," The Admiralty, Whitehall, S.W.1; inventions concerning the War Office, should be submitted to the Ministry of Supply, The Adelphi, John Adam Street, W.C.2; inventions concerning the Air Ministry, which are concerned with the operational side (for example—devices for detecting the presence of hostile aircraft) should be submitted to the Under Secretary of State for Air, The Air Ministry, Kingsway, W.C.2. Those which, on the other hand, are concerned with devices and fittings for aeroplanes, should be submitted to the Secretary, The Ministry of Aircraft Production, Millbank, S.W.1.

Any inventions sent to these addresses will be considered, and if necessary, passed to the specialist branches concerned.

In some quarters it is considered not improbable that the introduction of the Purchase Tax will result, to some extent, in a revival of the home construction of radio receivers. The reason is because complete receivers and radio-gramophones are taxed at 33⅓ per cent of their wholesale value, whereas components are for the major part exempt. Although valves are subject to the tax, it is clear that, particularly with mains-operated receivers, a considerable saving could be effected, as the valves are the only component parts taxable. Batteries and accumulators come within the scope of the tax and, therefore, no considerable saving could be effected in the case of battery receivers.

It is fairly evident, however, that owing to the difficulty of securing raw materials there will be comparatively few components on the market and the quantity available will become less as existing stocks become exhausted. According to Mr. A. J. Dew, President of the Radio Wholesalers' Federation, the amount of the tax on an average receiver will be approximately £2. Taking into consideration the possible saving which can be effected, the limited supply of components which will be purchaseable and also present conditions, our view is that only a negligible amount of interest in a revival of home construction will develop.

As with other commodities the tax will not apply to receivers obtained by the retailer before the introduction of the tax on October 21.

COLUMBIA COLOUR TELEVISION

FIRST DETAILS OF AN ENTIRELY NEW SYSTEM

Dr. Peter C. Goldmark (left) C.B.S. Chief Television Engineer and inventor of the new system of colour television, and J. N. Dyer, Assistant Chief Television Engineer, operating the colour television projector which was publicly demonstrated for the first time on September 4, at the Columbia Broadcasting System laboratories, New York.

As was briefly reported in last month's issue, television in full colour for practical broadcasting was successfully demonstrated by the Columbia Broadcasting System on August 29. The colour television pictures that were demonstrated used the same frequency band width required for ordinary black and white images.

Dr. Peter C. Goldmark, C.B.S. Chief Television Engineer, invented and developed the system, and independent reports state that the pictures appear to have a greater and more faithful range of shade and vitality than exist to-day even in colour motion pictures, and that it has been found that the use of colour actually increases the apparent definition of the picture and makes small objects easier to recognise.

Dr. Goldmark, was born in Budapest, Hungary, in 1906. Immediately following graduation, he was employed by Pye Radio, Ltd., in Cambridge, having control of its television activities. He remained with the British company until 1933. After a brief period as a consulting engineer in U.S.A., Dr. Goldmark joined the Columbia Broadcasting System in 1936 to participate in its research and television activities. Later, as Columbia's chief television engineer, he supervised the installation of the television transmitter on the top of the Chrysler Building.

Present State of CBS Colour Television

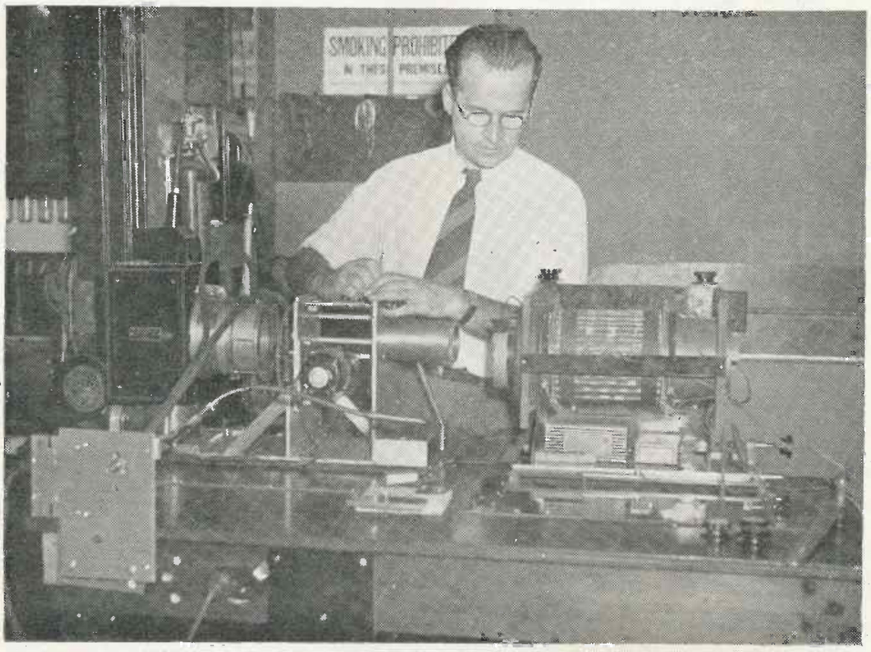
C.B.S. colour television is at present in the fourth of five stages of laboratory development, with three important steps behind and another still to be completed.

The first stage of development was the application of the optical and electronic methods to the practical problem of creating a picture in full colour. This consisted of scanning a coloured image, breaking it down into a television line structure, transmitting it and reassembling the many electrical impulses into a colour replica of the original subject. This was done by developing special pick-up or scanning equipment, using it to scan a glass slide containing a full colour photograph of a girl in costume, transmitting this picture to a specially constructed receiving set in which the image appeared as a picture approximately $2\frac{1}{2}$ by 3 inches in size. The success of this experiment verified the soundness of the theoretical data on which the process is based.

The second stage of development involved adding motion to colour, to determine if the optical and electrical systems were capable of transmitting and reproducing motion picture film without a breakdown or separation of colour. This required the special construction of an experimental film scanner. The completion of the first motion picture scanner at present used leaves room for further improvement; demonstrated, however, the system was capable of transmitting motion with high fidelity of colour and within nominal limits of speed (critical speeds remain to be tested).

The third development stage consisted of adapting a standard black-and-white television receiver with a 9 in. cathode-ray tube to receive colour, and substituting it for the specially constructed colour receiver used in the first stage of the experiments. This was successfully done and it promised that colour television receivers are practical from a manufacturing and production viewpoint.

The fourth stage consisted of an actual test of the colour system by radio to determine whether the system would function properly under ordinary condi-



This photograph shows the optical part of the colour television transmitter.

tions of actual broadcasting. This was done successfully on August 28, in order to effect this test before basic reconstruction of the transmitter was begun to permit it to operate on its newly assigned wavelength.

While this test, in a literal sense, took the developmental work out of the laboratory, it is still considered a stage of laboratory development since it utilised both pick-up and receiving equipment of laboratory character. This test verified the premise that full colour television could be confined within the standard 6-megacycle wave band (within 4.25 megacycles for the picture itself) because the transmitter itself cannot transmit a wider band. Ordinary Kodachrome photographs were made of the received picture as it appeared on the end of the tube in the receiving set. The fifth stage of laboratory development, which is yet to be completed, is the construction and testing of direct pick-up equipment in contradistinction to scanning motion picture film. Work on this problem is being carried on, and it is hoped that before next January direct pick-ups will have been successfully demonstrated. This phase of the work may, however, require the development of pick-up tubes not yet available, and may therefore need the co-operation of manufacturers who specialise in this field.

The commercial stage of development of the entire CBS colour system must, of course, begin when the foregoing laboratory development ends. Columbia is not a manufacturer of television transmitting or receiving equipment and expects to entrust the production of commercial equipment to manufacturers in that field.

Technical Details

The present film scanning equipment uses 16 millimetre motion picture film taken at 64 frames per second and run at 60 frames per second. Work is now proceeding on film scanning equipment which will use 16 millimeter film taken and run at 24 frames per second. After this is completed, 35-millimetre equipment will be constructed as a natural extension of the film scanning development. (No new technical problems seem to be involved in these two additional film scanners).

The present picture contains 343 lines interlaced. Dr. Goldmark is experimenting to increase this number of lines to above 400 without exceeding the 6-megacycle band, and believes it to be possible. This in itself is not, however, a predetermined ideal, since, as stated, the addition of colour seems to add greatly to the apparent detail and definition in the picture. Therefore Dr. Goldmark feels that the ideal number of lines and the ideal method of interlacing involves an optimum rather than a mere maximum number of horizontal lines. This is the subject of further experiment.

During the last several years of general television development, it might be said that engineers have concentrated on the question "How much can be compressed into how little?" "How much" in this problem has been a question of how much detail could be secured in the television picture. "How little" has been represented by the space required in the ether to transmit the picture. "How little" has been answered by the Federal Communications Commission in setting the wave band for a television transmitter at 6 megacycles. The practical question then became how much could be compressed into those 6 megacycles.

The direction in which engineers have worked has been toward securing the greatest possible number of "lines" and the greatest possible number of picture elements within each line, to compose the picture. It has been commonly assumed that a 441-line picture in three colours would require approximately three times as much space in the ether as the same picture in one colour. Parallel with this, it has generally been assumed that the equivalent of three pick-up cameras would be necessary, each one picking up one colour component. It has thus appeared doubtful that full colour could ever be compressed within 6 megacycles without greatly reducing the number of lines in the picture.

Instead of asking "How much can be compressed into how little?" Dr. Goldmark asked a totally different question, "How long does the eye remember?" Approaching it from this standpoint, Dr. Goldmark asked "Do we need three complete pictures, each in a separate colour, to take the place of each black and white picture? Or can we have a succession of three pictures each in a different colour, but each following the other so swiftly that the eye blends all three into a single full-colour image?"

The answer to this lay in the human retina. The only possible answer was a pragmatic answer. Dr. Goldmark developed a system to test, as it were, the human eye and found that it does, in fact, "remember" well enough to produce a perfect illusion of simultaneity of colour when exposed to this new system of colour television.

The technical details of accomplishing this are as follows:—

1. A colour motion picture is run through a film scanner. Between the film and an electronic pick-up tube there is a rotating disc containing red, green, and blue filters in that order. When the red filter is in front of the tube only those parts of the picture which contain red register in the pick-up tube. When the green filter is in front of the tube only those parts of the picture which contain green (and this includes yellow) register in the tube. Similarly wih the blue filter.
2. The three filters (red, green and blue) are balanced to give the effect of pure white when the picture is white.
3. Synchronised with the disc in front of the pick-up tube is a similar disc in front of the receiver tube. In other words, at the instant when the red filter is in front of the pick-up tube, a red filter is in front of the receiver tube. The same holds for the green and blue.
4. The scanning method differs somewhat from that used in most black and white systems. The picture is *completely* scanned every sixtieth of a second instead of every thirtieth of a second. However, at the end of the first sixtieth of a second only two colours have been used. The third colour requires an additional one one-hundred-twentieth of a second, bringing the total to one-fortieth of a second for a single picture in full colour.

The following sequence may help to make this clear:—

The odd number lines are scanned in red in 1/120th of a second.

The even number lines are scanned in green in 1/120th of a second.

At this point the whole picture has been scanned, but there is yet no blue in the picture. Time thus far: 1/60th of a second.

Now the red on the odd number lines has faded and these same lines are scanned in blue in 1/120th of a second.

At this point the whole picture has been scanned one and one-half times, but in full colour only once. Time thus far: 1/40th of a second.

Now the green on the even number lines has faded and these same lines are scanned in red in 1/120th of a second.

At this point the picture has been scanned twice, but in full colour only once and a third. Time thus far: 1/30th of a second.

Now the blue on the odd number lines has faded and these same lines are scanned in green in 1/120th of a second.

Time thus far: 5/120ths of a second.

Now the red on the even number lines has faded and these same lines are scanned in blue in 1/120th of a second.

At this point the whole picture has been scanned three times and in full colour twice. Elapsed time thus far: 1/20th of a second.

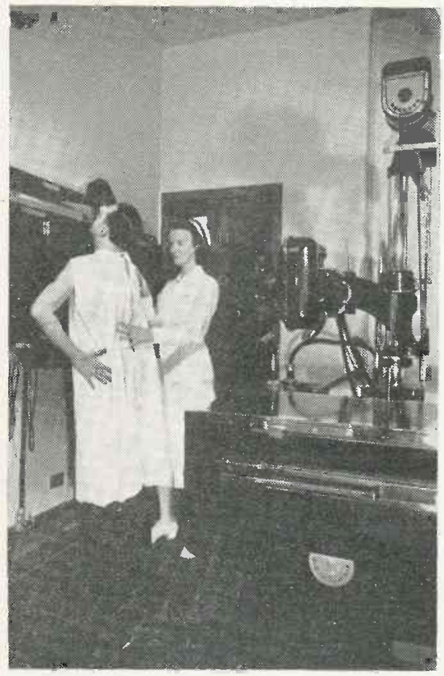
And now the whole progressive cycle begins again with the even number lines scanned in red.

5. When there is no colour disc in

(*Continued at foot of next page*)

NEW AUTOMATIC X-RAY APPARATUS

Timing Within 1/60 Second



X-ray exposures of 1/60th of a second can now be made by the Fluoradex X-ray apparatus. In an adjoining room the automatic control will operate the equipment at the touch of a double-trigger electric gun.

X-RAY apparatus operated by an "electrical brain" which "thinks" and acts with superhuman speed and precision has been installed in the Englewood Hospital, U.S.A.

The new apparatus, which has recently been developed by the Westinghouse X-ray Company, Long Island City, is capable of taking automatic pictures of human subjects in 1/60 of a second, with perfect safety. The speed at which these "stop action" pictures are taken is fast enough to depict the delicate structures of a beating heart or a breathing lung. The new camera is also specially designed to include facilities for examining patients of heavy build.

Twenty electric relays are an integral part of the machine's "brain" and these automatically accomplish functions hitherto done by the technician. They cause the machine to go through a series of intricate motions, of which the taking of the X-ray picture is but one. The operator, however, has complete control of the apparatus so that any desired technique can be applied.

The Fluoradex, as this new apparatus has been called, is the first device of its kind with a fully automatic control board. Previously it has been necessary for the X-ray technician to make intricate pre-settings of the X-ray tube filament heat in order to control the current during the exposure. This function is now completely automatic and is controlled by the robot mechanism, so that the technician merely sets three pointers which indicate his technical factors, voltage, current, and split-second timing.

The new automatic control is one of the latest developments to make intricate X-ray apparatus fool-proof. The operator of the Fluoradex controls the machine by means of a double-trigger electric switch which somewhat resembles an automatic pistol in appearance. When the trigger is pressed, the robot mechanism responds with lightning speed. It is so designed that the larger of its two triggers operates a series of electric relays in such a way that the finger pressure on the smaller trigger cannot energise the X-ray tube until its target anode has acquired a speed of 3,100 revolutions per minute. When this tube is operating at 500 milliamperes, 60 horsepower of energy is momentarily released. Were this power to be released too soon, the X-ray tube would be ruined.

Stereoscopic Pictures

By use of the double-trigger apparatus, it is now possible to take two pictures, for stereoscopic use, in a fraction of a second with complete accuracy and with mechanical precision. The advantage of stereoscopic pictures is that when viewed the patient's body is seen in three dimensions, that is, it looks like an actual anatomical model instead of a flat picture. When the larger trigger is pressed the voltage is raised to the point automatically set for operation. Then the rotor of the rotating anode X-ray tube is set in motion and an automatic circuit to operate the stereoscopic apparatus is ready to function.

While the five relays operated by the larger trigger are in position, the smaller trigger operates another series of electric relays which in turn cause the first film to be exposed, then bring up the second film into position and adjust the apparatus so that the angle of view for the second stereoptic picture is governed with absolute accuracy. After the exposures are completed, the circuit automatically resets itself and the camera is ready for another pair of stereoscopic pictures.

Timing is by an Ignitron and this can be pre-set for whatever exposure is desired. It can be as brief as 1/60 of a second. This timer turns a current of 200 amperes on and off in this short time interval without any arcing or burning whatever. This speed is the fastest in practical use by any X-ray camera. It enables the radiologist to "stop action" in the involuntary movements of body organs, such as heart beat, the movement of lungs while breathing and the peristaltic movement of the intestines. High-speed is of particular importance in the study of chest and abdominal conditions.

The target anode is rotated rapidly by use of the principles of an induction motor. By this means a high input energy of 500 milliamperes can be used on a small focal spot, which contributes to the fine definition pictures.

"Columbia Colour Television"

(*Continued from preceding page*)

front of the receiver tube the picture appears as a black and white image.

The receiver used in the colour demonstration was a standard production model adjusted to only a minor extent and equipped with a simple attachment, the cost of which should be comparatively small.

One of the most unique features of this colour method is that it makes possible reception of the picture either in full colour or in black and white. If the receiver is equipped with the colour attachment, it converts the signal into a full colour picture. If it does not have the colour attachment, it converts the same signal into a black and white picture.

C.B.S. does not intend to keep this new development for its exclusive use, but is already considering plans by which colour television can be made available to the public through manufacturers of television transmitting and receiving equipment.

* * *

Dr. Paul Nipkow, inventor of the Nipkow Disc, died in Berlin on August 24 at the age of 80. Although he secured a patent on his "electrical telescope" in 1884, it was not until the introduction of the valve that the disc could be put to practical use.

metals to which colloidal-graphited water is applied should have a coefficient of expansion approximating that of graphite.

High-tension insulators are also improved by receiving a graphite coating which reduces corona discharge. Another use in which the conductivity of graphite is exploited is the coating of the inside walls of cathode-ray tubes. The lustrous black surface on cathode-ray tubes is now a familiar sight and different manufacturers of tubes have adopted various methods of application.

As a contrast, the manufacture of variable resistances offers a good example. Fig. 2 shows such a component manufactured by Ferranti, Ltd., the resistance element of which has been formed with "Aquadag." Such a graphite coating is adherent and is highly efficient for the work which it has to do. Reference should be made to the employment of colloidal graphite to improve the contact between the caps of fixed resistors and the resistance rod. More common substances, such as conducting paints, amalgam pastes, mercury, and tin-foil do not always give intimate surface contact. A coating of graphite appears, on the other hand, to be ideal. Its ease of application, permanency, and boundary definition are especially noteworthy.

Thermopiles are especially suited for infra-red spectographic experiments when colloidal graphite is used as a radiation-absorbent. Likewise, small low-cost microphones may employ electrically-resistant films of colloidal graphite on the interior of carbon granule chambers.

An additional characteristic of graphite dispersions is the opacity of the applied film; a factor of some importance in photo-electric problems and special optical studies. Such applications are the coating of metal shutters, slit systems, diaphragms, and other non-reflective areas. The fine particle size and conducting properties of colloidal graphite ensure positive contact in copper-oxide rectifiers.

The use of "dag" colloidal graphite in oil for the lubrication of the selector equipment in automatic telephone exchanges throughout this country may be mentioned. A typical piece of equipment, manufactured by the Automatic Electric Co., Ltd., for which the above lubricant is specified is shown by Fig. 3. The ratchets and pawls of the selectors are given a periodic application of graphited oil. It will be apparent that the continuous lubrication of large banks of such units, as illustrated, would present problems, and it is therefore necessary to provide lubrication which will be lasting.

Perhaps one of the most practical industrial applications in the electrical world is the use on a big scale of colloidal graphite for the treatment of the threads of turbine casing bolts. It was found that, by applying a coating of graphite by such means, the threads of these large bolts were protected from seizure caused by heat and steam in the turbine.

Sealing Glass to Metal—A New Method

METAL and glass having different coefficients of expansion are difficult to seal together because the metal cracks the glass during cooling from the sealing temperature. Metal bodies, such as support wires and lead-in conductors, embedded in the glass press of a radio valve, often have a much higher thermal coefficient of expansion than the glass in which the wires are embedded. While the glass is molten or in the softened state it easily flows into contact with the metal, and, where the metal is slightly oxidised on its surface, an adhesive bond is established between the glass and the metal. As the parts cool, the glass solidifies and the metal tends to pull away from the glass, but because of the metal-to-glass bond, the metal stresses the glass, and usually cracks it.

A method of effecting a low strain bond between metal and glass, having different expansion characteristics such as nickel or nickel-plated iron support wires in the press of a radio valve stem has been developed in the laboratories of the Radio Corporation of America, by firing the wires in a hydrocarbon gas for a sufficient time to impregnate the surface of the wire with the gas. Probably some carbon and carbides of the metal are formed. When the metal is heated in contact with the glass, copious quantities of gas appear at the surface of the metal and blow bubbles in the glass in contact with the wire. These gas bubbles prevent wetting of the metal by the glass over the entire surface of the metal and apparently diminish the strains in the glass to prevent cracking.

Alternatively, the gas producing impurity may be applied to the surface of the wire in solid form. Carbon, either amorphous or crystalline may be coated on or impregnated into the surface of the metal; this when heated in contact with glass produces gas bubbles in the latter. Graphite or lamp black is conveniently applied in an inherent smooth coating to the surface when mixed with a volatile binder and sprayed on the metal parts. The metal parts may, if desired, be carbonised in the usual way by covering with a thin pasty coating of graphite carbon and heated to drive off the binder and cause the carbon to adhere to the metal. Carbonised nickel or nickel-plated iron wire or strips, when heated in contact with glass, produces a bond with the glass characterised by small bubbles in the glass at the surface of the metal. The bond is mechanically strong and the glass is free from visible cracks.

The foregoing method has been found to be particularly useful when sealing solid nickel wires or nickel plated iron wires into commercial soft glass, such as lead glass. It has been found that pure metals, such as electrolytic nickel will crack the glass, apparently because the metal is gas-free and permits too firm a seal with the glass. When electrolytic nickel is carbonised or fired in a hydrocarbon gas at a temperature of about 800 degrees C. for 10 to 15 minutes it can readily be sealed into a commercial lead borate glass without cracks. The bubbles are probably produced by absorbed gas released from the carbon as well as by gas resulting from reaction between carbon and glass.

Book Review

Television Receiving Equipment by W. T. Cocking, A.M.I.E.E. (Iliffe and Sons, Limited). Price 7s. 6d.

A treatise on television receiving equipment may seem out of place at the present time when no transmissions are available, but as the author points out, development in other countries is continuing and in order to follow such development and be in a position to take an active part in starting television again in this country after the war, it is highly desirable that interest in it here should not be allowed to lapse.

This book is devoted entirely to modern methods of cathode-ray tube reception and combines theory with practice. As a result, it is one of the most practical works on the subject yet published and deals in detail with the principles involved and the practical design of the complete television receiver. The scope will be apparent from some of the chapter headings, which include: The Cathode-ray Tube, Cathode-ray Tube Voltage Supplies, Electrostatic Deflection, Saw-tooth Oscillators, Vision-frequency Amplification, Intermediate-frequency Amplification, Radio-frequency Amplification, Superheterodyne Frequency-changers, Superheterodyne Interference Problems, The Detector, Sync Separation, Sound Reception, The Complete Receiver, Faults and their Remedies.

Some mathematical design formulæ is of necessity included, but generally the treatment is non-mathematical. For those who wish to obtain a sound knowledge of the principles of television receiver design, the book will be found invaluable and in our opinion is one of the most useful of its class yet published.