THE INSTITUTION OF ELECTRICAL ENGINEERS

FARADAY LECTURE 1964/65

COLOUR TELEVISION

by

F.C. McLean, C.B.E., B.Sc., M.I.E.E.

It is only fifteen years since Sir Noel Ashbridge gave the Faraday Lecture, taking as his subject: "Television". At that time, although the BBC Television Service was thirteen years old, because of the war, it was still confined to the London area. The total number of viewers was considerably less than $\frac{1}{4}$ million, and television was a novelty to most people. The number of viewers did not reach one million until 1952. Since that time, we have seen television grow at an enormous speed and become a major influence in public life, while the number of television sets in the United Kingdom has increased to well over 13 million. In fifteen years television has expanded some sixty times in the number of sets and has gone on to cover the whole country.

Fifteen years ago, colour television had been proposed and even demonstrated in an academic sort of way, but the prospect of a start of a colour service was very remote indeed. During these fifteen years however, colour television has advanced from an academic exercise to become a really practicable possibility for a public service.

In 1949, television existed in very few countries and there were very few receivers anywhere and no programme exchange between countries. Now, there are well over 100 million black-and-white sets in the world, and regular programme exchange of black-and-white television takes place all over the world, and there has been an experimental exchange of colour television.

Black-and-white television has brought us forms of entertainment, information and education in the home which would have been quite impossible by any other means. It has made us conscious of world happenings as never before, and we see things as they happen all over the world; and yet, although we are so glad to have black and white, we do lose quite a lot through the lack of colour. We see the world presented in various shades of grey. Admittedly, our imagination does a lot to supply the missing information, but, as red ~~and green both produce~~ green and blue all produce about the same shade of grey, we still have difficulties in fully interpreting what we see. How attractive it would be, if the picture you have all been looking at for the last few moments became coloured. (pause). We now see much more detail in the picture. It becomes brighter, and I think gives more enjoyment. (pause). That was of course a film but // Let us turn to a live picture from our studio here.

Start of flower film: b & w and then colour in sequence (15 secs. each . = 2 mins.)

It satisfies our curiousity too. These two good-looking girls (pause); are they brunette? What are the colours of their eyes? What are the colours of their dresses? When we see these things, we feel we know more about them, and .. gain even more pleasure in looking at them (pause).

Studio picture of girls: b & w (15 secs.) colour (45 secs.)

By our failure to see colour on black-and-white transmissions, we miss a lot. Not only do we find difficulty in distinguishing red roses from green foliage, but, because ~~red and green~~ very different colours give the same shade of grey, certain essential information can be entirely lost (pause). This caption in colour is quite clear, but, if we see the same caption in black and white only, the meaning is completely changed (pause). The red on it ~~is~~ produces about the same shade of grey as ~~the green~~ does the blue of the background.

Caption : colour (10 secs.) b & w (10 secs.)

We can see the attraction of colour, but let us see what is involved in adding colour to normal black-and-white television.

Three hundred years ago, Sir Isaac Newton showed that white was a mixture of colours and could be produced by revolving a multi-coloured disk and that, when the speed became so fast that the eye could no longer distinguish the separate colours, an effect of which light was produced (pause). However, this is reflected light, and for colour television we need of course to produce direct light.

Disk
30 secs.

We all know that white light is composed of all the colours of the rainbow and, if we deflect white light through a prism, we see all these colours, going from red to violet, displayed in the well-known spectrum. If it were possible to take all these colours and recombine them, we should of course reform the white light. But, by a most fortunate characteristic of the human eye, we find that, to produce white light, or something that looks like white light, we need not recombine <u>all</u> the colours, but not more than three of them, and combine these in suitable proportions to achieve the required white light.

Spectrum appears and stays until marked on page 4

Three suitable colours are particular shades of red, green and blue, and are known as the additive primary colours. You will notice that these additive primaries are different from the reflective primaries of red, yellow and blue that we became accustomed to in water-colour painting. One of the first lessons to be learnt in colour television is that the primaries are not red, yellow and blue, but red, <u>green</u> and blue.

I will now produce spots of these particular shades of red, green and blue, which match particular shades in the spectrum. By adjusting the intensity of each of these colour light sources so as to control the amount of that colour falling on the spot where all the colours overlap, I can get a colour that seems to me to be white. I say 'seems to me' because various people have different ideas as to what is a true white. We can have a yellowish white - a bluish white - a reddish white.

Demon^{n}. until page 4

We can also produce a wide range of colours. | Demon^n. continued

You will see that green overlapping red produces - perhaps somewhat surprisingly - yellow; Magenta is there, from blue overlapping red. What we call cyan, which is a sort of turquoise, comes from green overlapping blue. Changing the brightness of each gives further combinations of colours.

If we know the mixture of the primary colours making up any given colour, then we can identify and reproduce the colour exactly; every shade of colour has one combination of primary colours only.

We know that colours look different when viewed in daylight, or in artificial light which appears to be white, as the eye judges colour against the general light of the scene. For colour television, we must choose a form of white which will give faithful colour reproduction whether we see a picture originating from a studio with artificial light or from an outside broadcast in daylight. We have to show television pictures with the same settings on the receiver and in the transmission path irrespective of the origin of the picture, and we must therefore choose a white which is intermediate between the brightness of the summer sun and the brightness of an indoor scene. The white chosen for colour television has been standardised at a particular value. As a matter of interest, it is in fact the white of the northern sky on a winter's day. This white is produced by using definite proportions of the red, green and blue primaries.

You can see that if, instead of projecting plain spots on the screen, I were projecting pictures, then the colour of the picture could also be changed according to the intensity of the separate colours used; and I could produce a picture of any shade. If the mixture of the colours were varied appropriately over the whole of the picture area, as the picture brightness and colour varied, and of course the three pictures were accurately superimposed then I should get a normal colour picture.

End of spectrum and spots

The problem of colour television is in many ways similar to the problem of colour printing. In colour printing, the same picture is laid down in the various colours on the printing process on the same piece of paper, each picture accurately superimposed on the other. In printing, any departure from accurate superposition is immediately apparent, and so it is in colour television.

The basic problem of colour television is therefore to produce simultaneously from the same scene a red picture, a blue picture and a green picture, and to find means of enabling the viewer to see these three pictures simultaneously and accurately superimposed.

The essence of the problem, at the studio end, is to analyse and separate out the components of the picture in the three colours; then to transmit these signals over the whole chain in the most economical manner and then at the receiver end to recombine them.

The actual process of producing the colour pictures is of course identical with that of producing a black-and-white picture in so far as the picture is scanned line by line, and the scanning is repeated fifty times every second. But instead of being done only once as in black-and-white television, it is done simultaneously but separately for each of the three colours.

When a colour service is started, it will have to be carried on the same channels as are used for existing black-and-white transmissions. The number of colour receivers will initially be low, and in any case it seems highly improbable that the number of colour television receivers will ever be 100% of the audience, and It is clear that we cannot afford that the screens of viewers having black-and-white only receivers should be left blank while a colour transmission is in progress. Also, when a colour service does start, such transmissions will necessarily represent only a few hours a day, and viewers will want to receive black-and-white pictures on their colour receivers for the rest of the time.

Therefore, not only must a good colour picture be produced but a viewer with a black-and-white receiver must be able to look at the transmissions and get a black-and-white version of the colour picture. Also the viewer with the colour receiver must be able to receive normal black-and-white transmissions as though he were using a black-and-white set. This is called compatibility, and is an essential requirement for a colour system. The compatibility requirement killed the earlier and in some ways simpler sequential systems of colour television

At the present time, there are three systems under consideration in Europe - the NTSC system originating in the United States, the SECAM system which is a variant of the NTSC system and originated in France, and the PAL ~~system originating in France and the PAL system originating in Germany~~ system, another variant which originated in Germany. All possess the basic characteristic that a signal which determines the brightness content of the picture is sent as in black-and-white television, since all that is needed to produce a black-and-white picture is a signal determining brightness of the picture. This signal is known as the Luminance Signal and enables the compatibility requirement to be met. The signal which determines colour is sent separately and is known as the Chrominance Signal. Briefly, luminance gives brightness and chrominance gives colour. I shall be referring to these terms frequently. The difference betwenn black-and-white and colour television resides in the chrominance signal and its associated timing signals.

The differences between the systems reside in the different ways of sending the chrominance signal but, because all contain a luminance signal, all meet the basic requirement of giving compatible signals. All the systems have advantages one way or another, in the cost of the receiver to the public, the ease of operation of the receiver, the reliability of operation in the presence of interference and distortion, the quality of the compatible picture, capacity for future improvements, and so on.

There are considerable degrees of agreement between the three systems, and so, for the sake of simplicity in this lecture, I will deal only with NTSC, although most of what I say will apply equally to the other two systems.

At the present state of development, there is no doubt that we have the means of producing fully satisfactory colour television. The problem is, which is the best way to do it.

This question is under consideration by an International European Committee, and we hope that at a meeting in Vienna ~~next~~ 1965 year [1965: this year] a decision on a system which can be used in the whole of Europe will be taken. After this decision has been made, it is hoped that the Postmaster General may be able to announce a date for the start of a colour service in the United Kingdom. The Postmaster General decided, on the advice of the Television Advisory Committee, that it would be desirable to include colour only on the new 625-line standards, and accordingly all the transmitter and programme distribution systems for

* In the case of a colour service, we shall not therefore have the situation that it will start in the London area and gradually spread over the rest of the country, but it will start on the same day over very large parts of the country.

get far before we start to talk about bandwidth and channels, but there is no need to be alarmed. As television viewers, we are all familiar with the idea of a channel. A channel is that amount of wavelength space which is allocated for the transmission of a television picture.

In all forms of television, transmission and reception of more fine detail than is really necessary costs money and increases the difficulties at all stages of the process, including the receiver. We are therefore concerned that the amount of fine detail in the picture to be transmitted shall be kept to a minimum, consonant with obtaining an adequate picture. The space available in a broadcasting channel is fixed, and all the signals required for both the black-and-white and colour transmission must be confined within this space, which at one timewas thought to be fully utilised in transmitting black-and-white, or luminance, information only. Now, however, we have, without spoiling

the quality of the black-and-white picture derived from the luminance signal, to introduce colour, or chrominance, information into the same channel. The more the bandwidth required for the chrominance signal, the greater the crowding of the channel becomes. The finer the detail transmitted, the more bandwidth or frequency space required. If we try to put more fine detail in the channel than can be accommodated, we shall spoil the quality not only of the colour picture we are trying to produce, but also the quality of the black-and-white picture we must preserve.

To make the problem of finding room for the chrominance signal as simple as possible, we must send out as little detail as we can about the colour, so that the amount of bandwidth used for its operation is as small as possible.

In order to reduce the bandwidth required for the chrominance, or colour, signal, we must examine whether it is necessary to send out all the details of the red, green and blue signals in order to obtain a satisfactory colour picture. Experiments to find out how we see colour have shown that the human eye sees fine detail only as black and white - that is, we can see the brightness changes, but accompanying colour changes in this fine detail are lost. This can be illustrated by a very homely example. If a thread of cotton is unwound from a reel and held away from the eye, it is common experience that we cannot recognise its colour although the colour of the whole reel, which is a much bigger area, is perfectly clear. For large areas, we require full information of the colour but in fine detail we do not. Provided we have the full detail in the Luminance Signal, we can do with much less detail in the Chrominance Signal, and therefore we do not need the full detail, or bandwidth, for each colour in order to produce a satisfactory picture.

Demon^{n}. Girl with reel of coloured cotton

We are now beginning to build up an idea of what our complete colour signal should be like. We have agreed that we shall have to send a Luminance Signal conveying brightness and all the fine detail, which in itself uses the whole channel space. Now we have to add the signals to send the colour, or chrominance, information. We have already seen that we require to mix together three coloured primaries in order to produce a colour picture, and therefore we must have signals to control the brightness of each of these coloured primaries. We already have one signal in our colour system, that is, the Luminance Signal, containing components derived from all three colours. If therefore, in the chrominance signal, we send information on only two of these colours, then we shall be able, at the receiver, by a ~~by a process~~ process which I shall explain later, ~~at the receiver~~ to derive the third. Therefore we have to send two pieces of information in the chrominance signal, both of which have reduced detail or bandwidth. These two pieces of information are identified by letters and are known as the I and Q signals. Our complete signal is therefore the Luminance Signal plus the I and Q signals, and all these must be packed into the existing channel space.

Now, we have to see how we can produce this signal. I should perhaps here make clear that, when I say that certain signals can be added to the black-and-white signal to make a colour signal, this is not saying that I can add anything to a black-and-white receiver to make it into a colour receiver. This is definitely not possible.

If I look at a scene through a lens, and then follow the lens with an optical device which divides up the light into red, green and blue paths, and then put a television camera in each of these paths, I will get separate red, green and blue signals, each at this stage containing all the detail present in the scene in that colour. There are several ways of dividing up the light, but the way

morning:)
afternoon) we shall see tonight is the use of a form of a set of mirrors which have the property of passing some colours of light directly to the lens of the camera, while other colours are reflected. The mirrors are so designed as to pass through or reflect the red, green and blue content of the picture.

We see this in the demonstration, in which I take white light, pass it through the mirror system (pause), and we shall see that the red, green and blue components of the light are separately distributed to the three devices known as photocells, which I have put in instead of the cameras. In the output of these photocells, therefore, I have put indicating devices, ~~watch the meters~~ which are being viewed by the camera in the studio, which show me the intensity of each of the lights coming through the system. I see that the intensity of the red light, the green light and the blue light, as shown by the indicators, is the same. The readings on these indicators represent the signals which, at the receiver, control the amount of red, green and blue primaries. In this case, with white light entering the camera, the signals produce the right amounts of red, greenand blue light at the receiver to give the effect of a white screen - in fact, the standard white to which I have already referred. As I vary the colour of the light falling on the system, the readings of the indicators change. If I pass a red light into the system, then I see I have light going into the red photocell but none in the green and blue. Similarly with other colours of light.

Demon^{n}. starts

4 mins.

We can see another important thing from this demonstration. If now I come back to white light and vary the intensity of the white light in front of the colour analyser by the insertion of a light-absorbing filter, you will see that the indicators all vary together, having the same reading for any particular intensity of white.

Thus, we can send information about brightness, which is just what we need for the luminance signal, by adding together fixed portions of the red, green and blue signals from the camera, while the chrominance signal identifies the colour by means of the varying ratio between the red, green and blue camera signals.

In normal operation, the broad balance between the colours in the system is set in the design of the cameras, but we can make final adjustments to the balance electrically outside the camera. This is done in the studio, and the final adjustment is always done on a picture of the human face. This is because the eye detects immediately any abnormality in flesh tones, but is very tolerant of departures from absolute fidelity in the colour of clothing, scenery, flowers, etc. In this picture from the studio, we have made this balance very carefully so as to get good flesh tones. We have of course no means of knowing whether or not the colours of the dresses and the materials are accurate, but if they look reasonable we accept them for what they are. However if the flesh tones do not look reasonable, we should be inclined to reject the whole picture.

Girls: 30 secs.

Lights up

In the studio therefore we have analysed the picture, derived the separate red, green and blue pictures, added these together to get the black-and-white picture for the luminance signal, and extracted from the red, green and blue signals as little as possible but sufficient information to form an adequate chrominance signal.

Now we come to the kind of equipment that we need to carry out these processes.

On these two diagrams, we have the complete colour television broadcasting chain, from the studio and transmitter on your left to the receiver on your right. As you know, we originate the pictures in the studio, pass them over lines to the transmitter, and radiate them from there. We receive in an aerial, use the signal in the receiver, and display the picture on a cathode-ray tube. All this is shown in diagrammatic form. Turning now to the studio end -

On the scene at the far left, we will display a plain Demon^{n}.
colour. With red on the scene, you will see that, after passing
through the Camera Optical Colour Analyser, a red signal reaches 10 secs.
the Electrical Colour Analyser (pause). Similarly green
produces a signal only in the green chain (pause). 10 secs.
Blue in the blue chain (pause). If I put on what we call 10 secs.
cyan - which as I have said is a kind of turquoise - I shall
get signals in the green and blue chains (pause). If I put 10 secs.
on ~~yellow~~ magenta, I get red and ~~green~~ blue. (pause). If I put on 10 secs.
~~magenta~~ yellow, I get red and ~~blue~~ green (pause). If I put on white, 10 secs.
I get all three colours (pause). And so, whatever colours 10 secs.
are shown on the scene, I get various combinations of red,
green and blue signals available to be fed from the Optical
Colour Analyser, which is the special mirror system, to the electrical part of the circuit.

If however, instead of being a uniform colour all over, the scene had a normal colour picture on it, then, as the scene is scanned in detail, from left to right, and from top to bottom, the output signal would contain varying components of the red, green and blue fundamental colours, dependent upon the actual colour existing at the spot being scanned. If the picture at a certain point is pure red, then only a red signal will exist. If it is green, then only green; if magenta, then we shall get red and blue. At each point the mixture of the three colours will determine the colour - what we call the tint or hue - while the intensity of the colour will determine the overall amplitude, that is, the strength of the signal.

What we have dealt with so far is actual light. At the output of the camera, the light is transferred to equivalent electrical signals. We deal with these in the so-called "coding" and "decoding" system. If at the end of the process, we apply these electrical signals to the reproducing device, we shall get back the precise colours which produced them in the first place.

That is, the coder takes the colour signals from the camera and wraps them up to obtain the best possible performance within the limitations of the bandwidth, while the correspondin

The decoding must of course match the coding. In colour television, there will perhaps eventually be a million decoders in the various receivers for every coder, and therefore one wants to make the coding no more complicated than it need be, so that we have the minimum total cost involved in the provision of the decoders in all the receivers used.

(A) At the Board

2 minutes -
Deal with balance of colours
White light luminance only
Colour luminance + colour signals I and Q
Variations in luminance, particularly luminance and combination of I and Q identifies a colour completely.

You will have noticed all the other winking lights, and I will explain these.

Theessence of all television is accurate timing, and you probably know what happens on a black-and-white receiver if timing circuits, usually called 'frame hold' and 'line hold' are not functioning correctly. You get break-up of picture and picture rolling. The timing, that is, the sequence in which line follows line and one complete picture follows another in your receiver, is not in step with the operations in the studio.

To enable us to pack the extra information required to give colour into the already crowded television channel, we have to use even more accurate timing. This can be done, but it does lead to the need for additional precautions, both at the studio and the receiver end of the chain.

(B) At the Board

2 minutes
Deal with Timing circuits
as for black and white
Special for colour

I would have liked to avoid the use of the words "carrier wave" and "modulation" but they are such an integral part of the problem that I cannot do so.

In television, as in all forms of electrical ~~information,~~ communication "carrier waves" are electrical waves used to carry the wanted signal from one place to another. In black-and-white television, such a carrier wave is used to convey the brightness information of the picture. In colour television, we use the same carrier wave to carry the brightness information, or as we call it the luminance information, and we use a special form of additional carrier to carry the chrominance information. The process of impressing the wanted signal on the carrier is called modulation, and the process of extracting the wanted signal from the carrier is called demodulation.

I have already said that the Luminance Signal is sent as in normal black-and-white television, that is, it is sent as modulation on the carrier wave. It will be asked how we can obtain all the information necessary for the reproduction of three colours by sending only two signals in the chrominance paths. (You will remember that I have already explained about I and Q). This is because I have in the Luminance Signal the electrical equivalent of all three colours and , if I subtract from this sum of the three signals the electrical equivalent of two of them, as shown in the Chrominance Signal, then I am left with the third.

The problem is therefore to send the two identifying colour signals, I and Q, in such a way that they can be separately identified. Normally we can on a single carrier only send one signal at a time, and we already have the black-and-white signal superimposed on the main carrier wave of the television channel. I can however superimpose two signals on a second carrier wave, and they can be sent simultaneously if I send them by special means.

This can be illustrated by a practice that used to be common in the nineteenth century when economy in letter weight and area was as important as economy in bandwidth is today. Two messages

* ..1840. This was actually sent from Malta to Windsor, and at that time cost 3/3d. It seems one of the rare instances where something in 1965 costs very much less than it did in the early 19th century.

writing which was vertical and my eye disregards the writing which was previously horizontal. By using this right-angle principle, I can send two clearly distinguishable messages in the same space or, put in electrical terms, on the same carrier. When reading this letter, we have to turn it round quite sharply from the horizontal to the vertical in order to display the information, and in colour television we have to do likewise, but electrically of course, and with a very considerable degree of precision.

(C)
At the
Board

5 minutes

Deal with Signal from Colour Carrier Generator
- Divides into two parts
- Modulate each separately
- Change amplitude picture
- Colour identification
- Position identification
- Colour in quadrant

Composition of complete signal

Having put the signal into this form, I can of course do with it all the operationsnow customary in television. I can mix the output of several cameras, the output of telecine machines, outside broadcast cameras, and the like, and of course I add on the sound component to the channel in the same way as is done in normal black-and-white broadcasting. I then have a complete signal ready to send to the transmitter network, to be transmitted over the air in the normal way and be picked up by the viewer's receiver.

What we have to do in the receiver is to unwrap in the decoder the signals which were wrapped up in the coder on the studio side, and a large part of the operations is the converse of what we did there.

By far the greater part, perhaps some 90 - 95%, of all colour receivers is the same, irrespective of the system used. All use the same type of picture display tube, and it is here that the principal cost is incurred. The differences between the three systems reside only in the manner of decoding the signal but, as on the transmission side I discussed the NTSC system only, I must continue to discuss this on the receiver side.

(D) At the Board

5 minutes
Go through complete receiver

Looking at the chain right through, if I put a red signal on the scene at the far left, we see that we get a red signal only going into the display tube at the far right. Similarly with a green signal; and a blue; and the various combinations of all the colours. If I put white on the scene, then I have red, green and blue signals going into the colour analyser . There is no colour to be transmitted and hence no I and Q signals. The luminance signal is going right through the chain, and at the end the luminance is being converted back into the red, green and blue, going into the picture tube. We have therefore an overall chain which faithfully reproduces a signal at the receiver end corresponding to the signal which was derived by the camera device from the scene at the far left.

Demon.[n] 40 secs.

Rear off

We could display these red, green and blue pictures on three separate cathode-ray tubes, and combine them optically through a series of mirrors in the reverse way to that used at the camera end, so that these pictures would be seen superimposed on each other. This process is the converse of the demonstration we saw earlier.

(E) [2 minutes Demonstration at Analyser] — Demon^{n}.

Such a system is however expensive and bulky, while the true superposition of pictures can only be seen if the viewer is sitting more or less on axis to the display tube. Arrangements of this kind were used to a considerable extent some years ago, but the advantages of showing a colour picture in a single tube were so marked that considerable work and ingenuity have been put into the development of such a device.

Before we consider the way in which we can produce the three separate colour pictures, it will perhaps be helpful if we look for a moment at the way a black-and-white picture is produced.

(F) [Description of b/w tube 2 minutes] — Slide 2 mins.

Now, let us consider the case of colour. Many types of colour tube have been developed experimentally, but only one is in commercial production so far. This is the so-called Shadow-Mask tube, and here I have a more-than-life-size model. It is called shadow-mask because it ensures that only the required areas of the phosphor screen are bombarded.

Slide colour tube

(G) [4 minutes Description of shadow mask tube] — model.

The three colour pictures which we have formed on the face of the shadow mask tube are slightly displaced one in respect of the other, because the colour dots are laid down side by side. This spacing is however very small, and the eye simply does not see it. I think we can illustrate what happens if we look at three slides.

In the first slide, we show the dots in a fairly large size and we can see the individual colours separately. (pause) If however we reduce the size of the dots, then they merge and, instead of seeing separate coloured dots, we see only the white resulting from equal intensities of red, green and blue, and the eye also loses the dot pattern.

Slide

Slide

Slide

I will now check the overall system by taking pictures from our studio here and going through the complete system in order. First we will produce a picture showing the red content of the scene. (pause). Next a picture showing the green content (pause). This shows considerable brightness and considerable detail. Now, the blue content of the scene, which you will see shows rather less detail and considerable brightness. We now add these three pictures together, and we see that we have a black-and-white picture which, although it is derived from three separate pictures superimposed one on the other, gives us a picture quality equal to that of a normal black-and-white camera.

Now we take the red, green and blue pictures, and we derive the chrominance signal from this, including in it only the minimum amount of picture detail and picture information required to give a satisfactory picture. As you will see, the picture looks a bit odd and there is not much detail in it. If however we add together the luminance and the chrominance signals, we get the complete colour television picture.

Having dealt at all stages with the very minimum of detail necessary to give a colour picture, I know I have gone as far as possible in reducing the cost of the receiver. I think I should perhaps repeat that, in adding luminance and chrominance information, I have made only a small difference to the transmitted signal, but this is not at all the same thing as saying that I can make an addition to a black-and-white receiver to receive colour. If I want to receive colour, I must have an entirely new receiver.

Now let us look at what could be a typical news item after we have a colour service. Film

(At the end of the State Opening scene, we go over to the girls in the studio who announce the film item. Girls Film
The approaching end of the film item is indicated by the butterfly in the fen scene. After the end of the film, the girls in the studio make the closing announcement: "That is all from the studio. Goodnight. Goodnight.") Girls

Well, that is colour television. I hope you will agree that it adds new dimension to television and gives a lightness and brightness to television that is not always present in the black-and-white version.

My thanks go to the very many of my colleagues and the ~~[illegible]~~ Film Dept who have helped with the preparation of this lecture, and in particular to Mr. Larkby and his assistants who have given invaluable help in the formulation and done so much hard work in the preparation and presentation of the demonstrations. I must particularly thank our two charming helpers X - Y in the studio.

~~I should also like to express my gratitude to Rank-Bush Murphy Company for the loan of the telecine and slide-scanner equipment.~~

MKPR
11.2.65 (part)

B.H.
Sheila Tracy

DUBLIN
CAROLINE RYAN
MARIDE CULLEN

Swansea 2
Miss A.E.M.Douglas
Miss Eileen Powell

Bristol 2
Miss Pamela Miller
Miss Sandra Nix

BELFAST
JOAN MACDADE
VIVYAN MACSHANE

Birmingham 3
Mrs. Gill
Miss MacNally

Portsmouth 2
Miss Holland
Miss Doreen Sharp

LONDON 17th 1
AVRIL GAYNOR
JANE BISHOP

BRADFORD 2
AFT. MRS MARGARET JOWETT
PM " " "

LONDON 18th 1
JANE BISHOP
HOIMA MCDONALD

MISS JENNIFER CLARKE

SHEFFIELD
BARBARA HAMMOND (BRUN)