The

Projected Picture Trust

INFORMATION SHEET NO.6

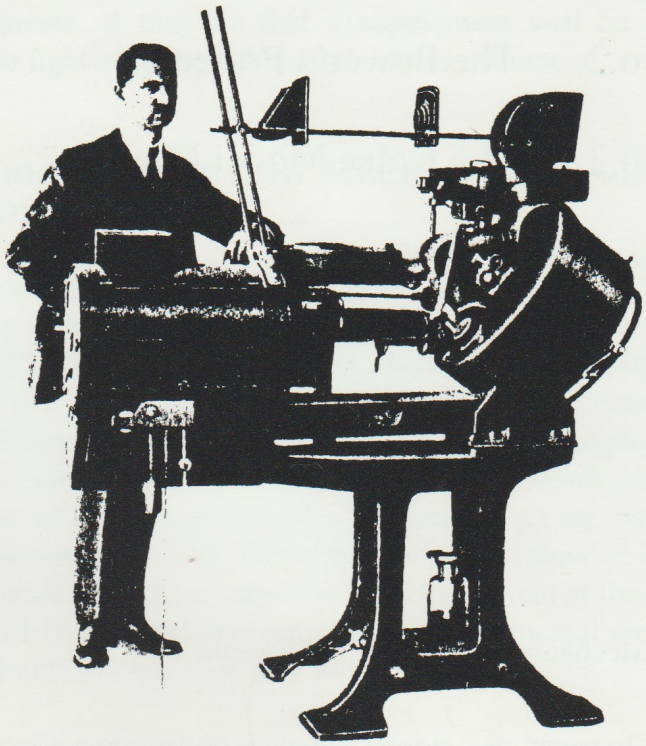
The

M E C H A U

Continuous Motion Picture Projector

by

Dick Hall



Researched and compiled by Dick Hall

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FRONT COVER. Emil Mechau and his Model 3 Projector

The
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INFORMATION SHEET No.7

THE MECHAU CONTINUOUS MOTION PICTURE PROJECTOR

Introduction

The dream of a continuous motion picture projection system,eliminating the conventional, stop/start intermittent movement, has long held a fascination for inventors. Some achieved a degree of technical success but, invariably, commercial failure. In Europe only the Mechau projector came anywhere near achieving success in both areas. While the Mechau projector, better known in the United Kingdom as the Arcadia projector, saw limited UK commercial operation, precise details of the machine, it's construction and development have not been widely publicised in this country. Our late Newsletter editor, Stanley Bowler, reviewed some of the published work in 1984/85 (1).

We are indebted to the Projected Picture Trust member Kevin Carroll whose fascination with continuous motion picture projection initiated a detailed literature search. His results were generously made available to the writer and stimulated further investigations. We have tried to present the evidence collected so as to indicate both the chronology and scope of Mechau's technical developments. It may be that a supplement will be required should further information come to light after the publication of this document.

1. THE CONTRIBUTION OF EMIL MECHAU TO NON-INTERMITTENT FILM PROJECTION

Although the name of Emil Mechau is universally associated with the Arcadia projector his researches over the years covered a variety of approaches to non-intermittent projection. Starting work at Rastatt in 1909 with the internationally respected optical firm of Ernst Leitz, his first patent in the field appeared in 1910 on "a patent cinematograph with optical compensation for film movement". Early patents disclose rotating lens and rotating tangential mirror systems (2.). Later work concentrated upon internal mirror drum systems. He produced a Model 1 machine which was sufficiently practical to go on extended trial in a Wetzlar cinema in the late summer of 1912. This projector had a throw of 100 feet to give a 20 foot picture and was considered to be a considerable achievement at the time (3.) It was followed by a Model 2 in 1914/16 (4.), and they remained in experimental service until 1921. The long test period was undoubtedly due to World War 1.

The basic principle of his projection system is simple - an image of the light source is caused to scan the continuously moving film frame by a moving mirror. This moving image is deflected by a compensating mirror moving in the reverse direction to give a stationary image, which is projected on to the screen. However there are major problems in achieving optically precise compensation. One of Mechau's key patents to overcome this problem was filed in

Germany on October 13th, 1919 and appeared in the UK as British Patent 152,347. The breakthrough occured on October 13th, 1921 with the commercial release by Leitz of a Model 3 Mechau projector into a Munster (Westfalen) cinema. The same year Leitz built a factory, Leitz-Kinowerke, which, by 1926, had produced 50 Model 3 machines (4.) A final version, Model 4, commenced production in 1926 but production at Rastatt ceased in 1929 with the coming of sound. Apparently Leitz felt that the new technology needed was outside of their field. The Mechau patents were taken over by AEG Berlin where, from September 1929, Emil Mechau was Chief of Production of their projector manufacturing operation. The Mechau machines continued to be made by AEG until 1934 and complemented their production of "Triumphator" and "Successor" Maltese Cross intermittent projectors (3. It was suggested by Tummel (4) that production of the Mechau stopped in 1934 because of high cost of manufacture and also possibly because demands for increased screen illumination could not be met. (This is at odds with claims of greater illumination efficiency for the Mechau). In all some 500 machines were made.

There was renewed interest in the Mechau in the early post-war years when its usefulness in telecine transmission was recognised. The BBC (12) certainly were using modified Mechau's for film transmission at this time. These may have been assembled from redundant projection machines. However, there is an interesting story - now legendary, told by Mike Orton (20). He states that just before the outbreak of World War 2 hostilities the BBC ordered four or five machines from Mechau (AEG?). Five years later as the American forces occupied Hamburg, several large packing crates containing these machines were discovered in the Mechau factory, addressed to the BBC and were duly despatched."

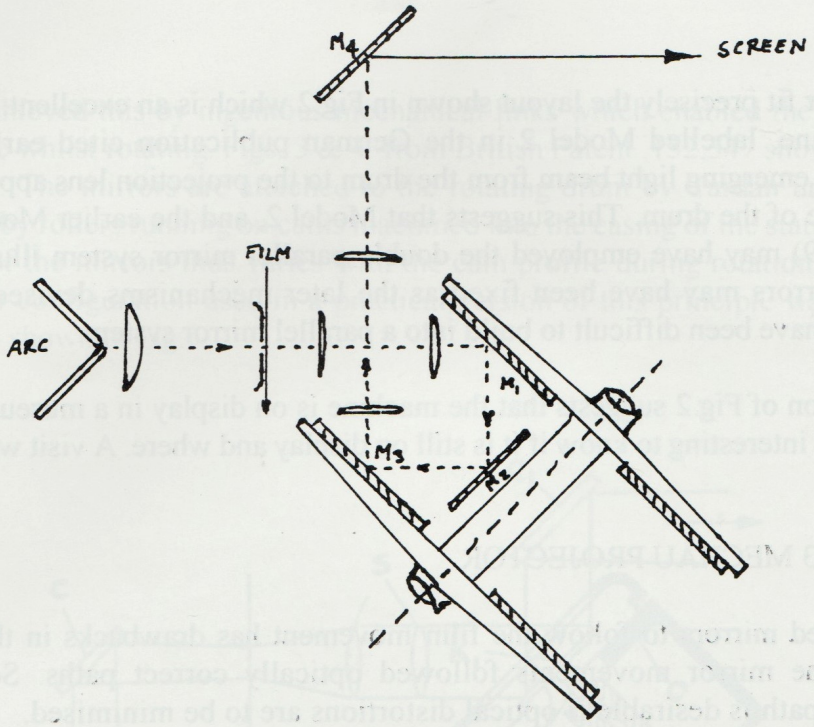
In 1931 Emil Mechau was awarded the Oskar Messter Medal by his profession in recognition of his outstanding services to cinema technology.

2 COMMERCIAL MECHAU PROJECTORS

The heart of the Mechau projector is the mirror drum construction. It is strange that for a machine which was in production for at least 20 years in Germany, one should have to speculate on the details of its mechanism. There were certainly two distinct, major types of mechanism which reached the commercial trial stage. Both were based on the mirror drum system, the earlier work on rotating lenses being superseded. We have already seen that there were four Model variants produced up to 1926. However only two major variants are visually distinguishable from published photographs available to the writer. In the absence of authoritative information it is surmised that the major change in construction occurred in the change from Model 2 to Model 3. Later modifications leading up to Model 4 were mainly inside the optical drum system and cannot easily be detected from photographs. It is worth looking at Models 2 & 3 more closely.

a) MODEL 2 MECHAU PROJECTOR

An early description of the Mechau principle appears in a 1922 book on Projection by Liesegang (5, 6). Fig 1. shows the optical path through the mirror drum which contains two parallel discs of mirrors. The tilt of the drum is at 90 degrees to the direction shown in other diagrams and photographs of the Mechau projector.



M2 & M4 static reflecting mirrors. M1 & M3 rotating mirrors

Fig.1. EARLY PARALLEL MIRROR DRUM SYSTEM

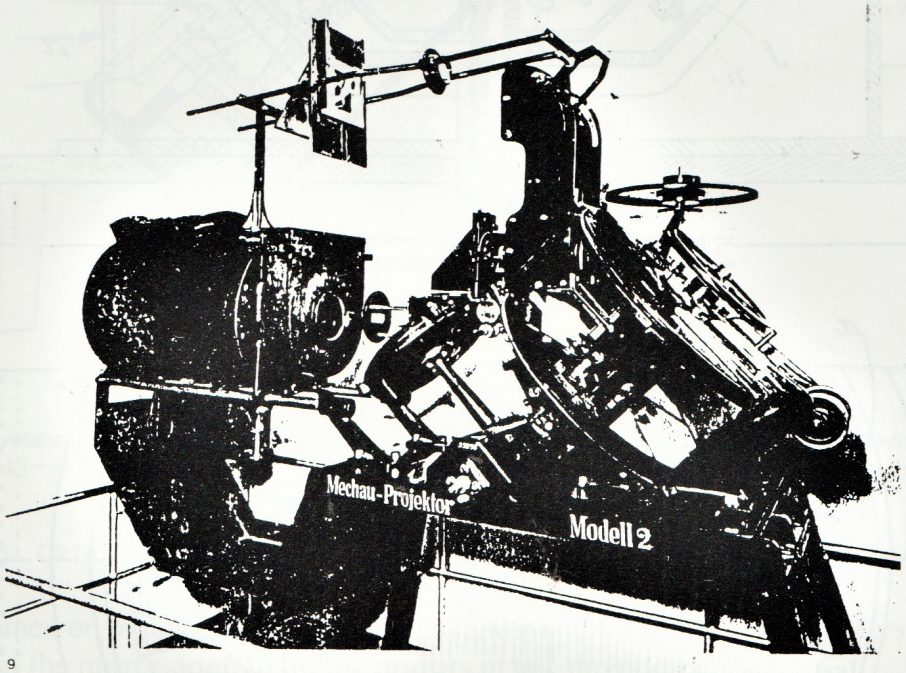


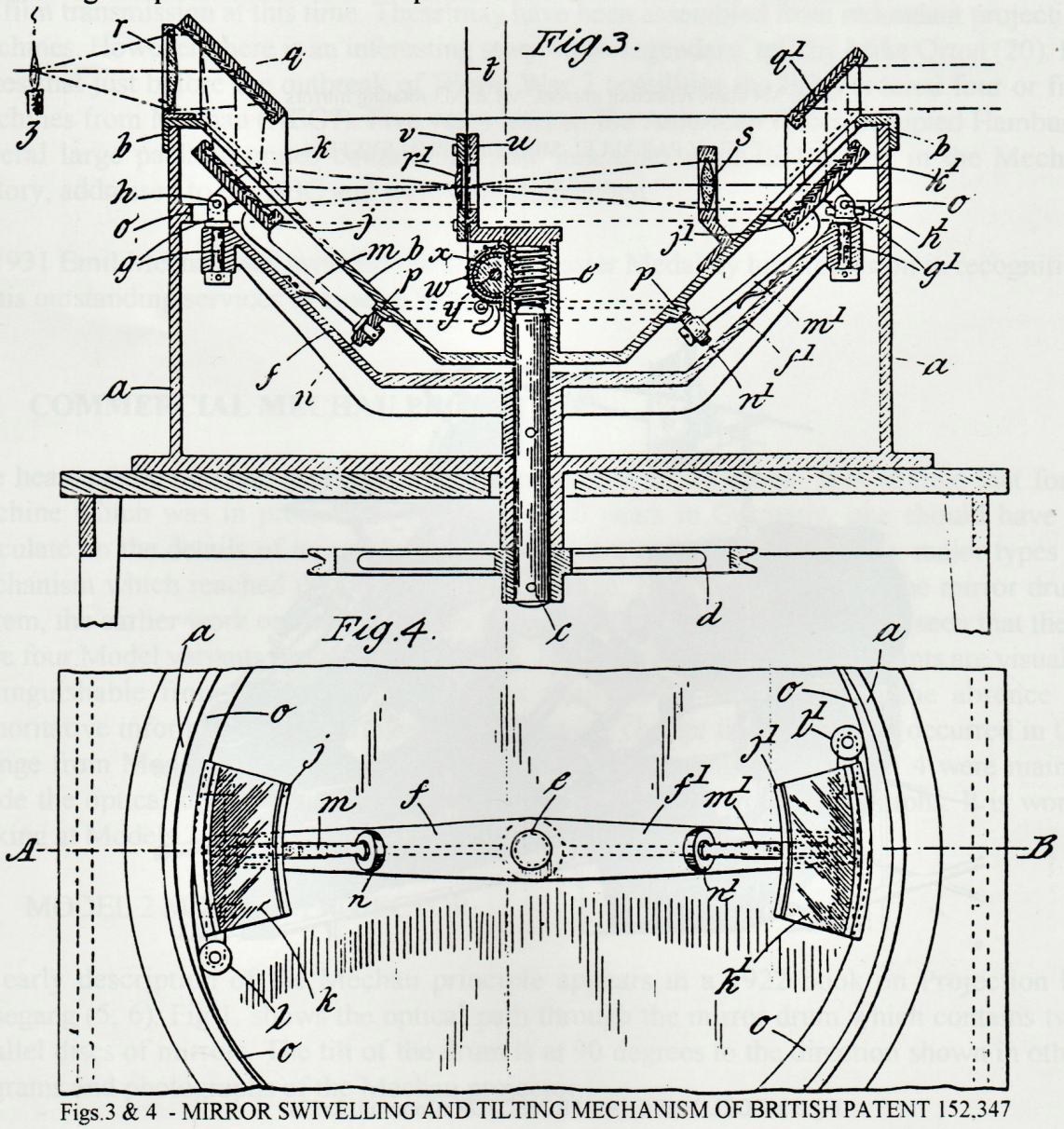
Fig.2 MODEL 2 MECHAU PROJECTOR (Cornwall, Ref.3)

It does however fit precisely the layout shown in Fig 2 which is an excellent photograph of a Mechau machine, labelled Model 2 in the German publication cited earlier (3). In this photograph the emerging light beam from the drum to the projection lens appears to be at the bottom left side of the drum. This suggests that Model 2, and the earlier Model 1 version of the Mechau (19) may have employed the double parallel mirror system illustrated in Fig.1 above. The mirrors may have been fixed as the later mechanisms devised for tilting the mirrors would have been difficult to build into a parallel mirror system.

Closer inspection of Fig.2 suggests that the machine is on display in a museum as it is railed off. It would be interesting to know if it is still on display and where. A visit would save much speculation!

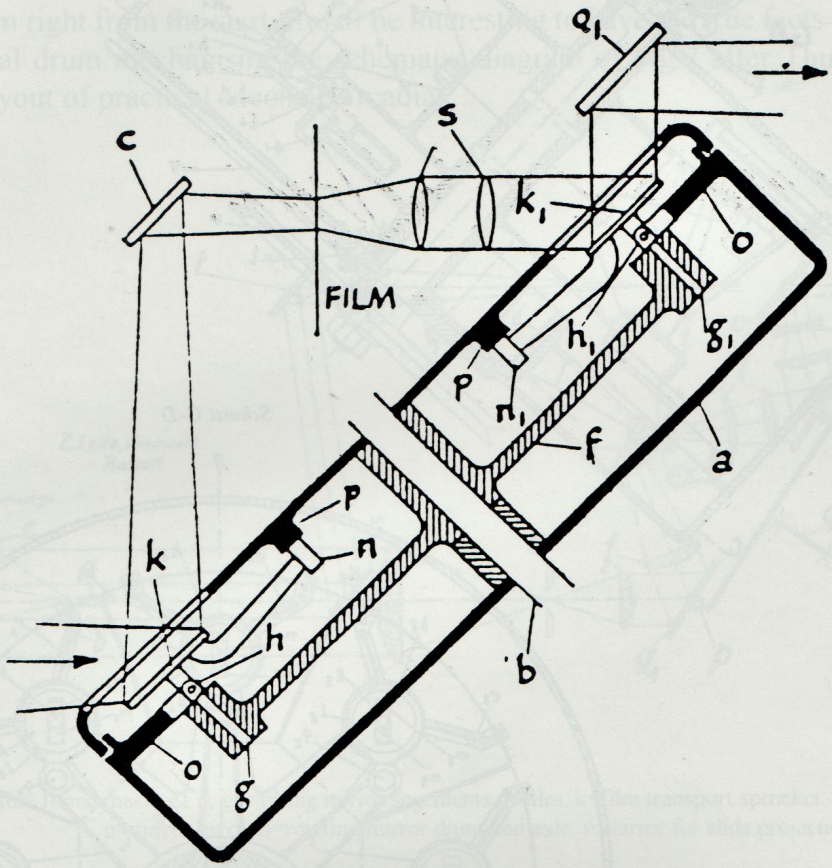
b) MODEL 3 MECHAU PROJECTOR

The use of fixed mirrors to follow the film movement has drawbacks in that it would be fortuitous if the mirror movements followed optically correct paths. Some means of correcting the path is desirable if optical distortions are to be minimised.



Figs.3 & 4 - MIRROR SWIVELLING AND TILTING MECHANISM OF BRITISH PATENT 152,347

Emil Mechau achieved this by ingenious mechanical links which enabled the mirrors to be tilted in any plane whilst rotating. Figs. 3 & 4. from British Patent .152,347 show one method of achieving this. The mirrors are attached to the rotating drum by Cardan universal joints which are driven by rollers running on cams machined into the casing of the static outer drum. The precise tilt of the mirrors thus varies with the cam profile during rotation of the mirror drum. The mirror configuration used in a practical version of this principle was outlined by Cricks (7). and is shown in Fig.5.



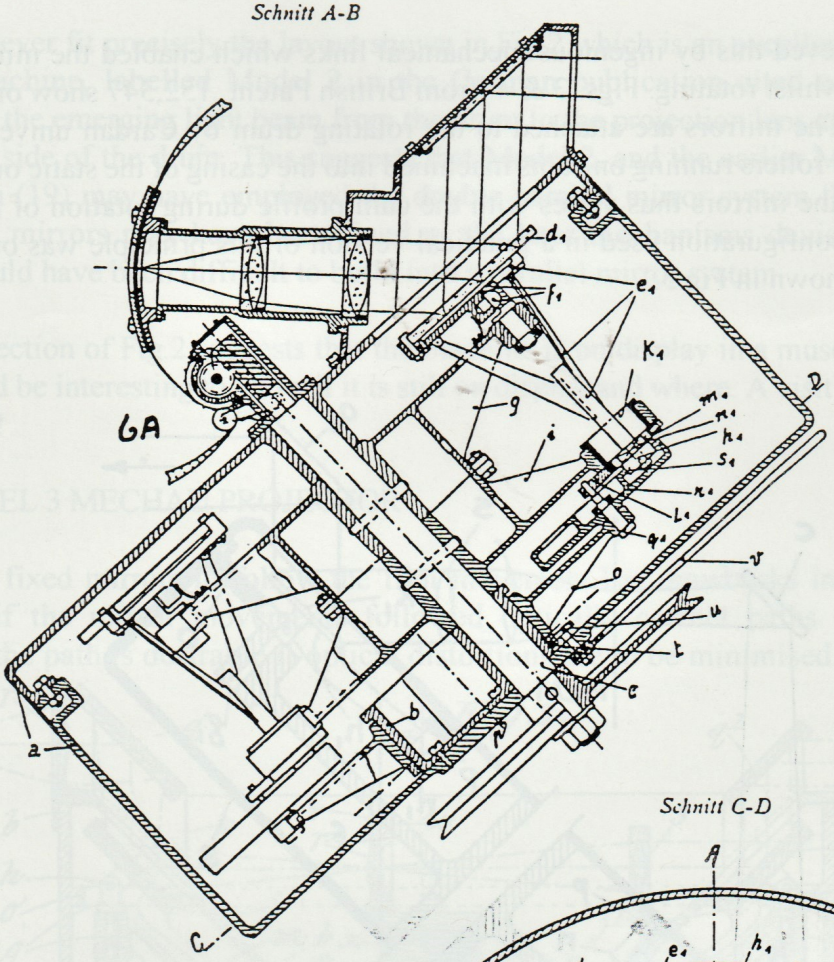
b= axis of rotation. f= rotating mirror drum frame. g & gl= bearing for mirror swivel. h & h1 =mirror tilting bearing. k & k1= rotating. swivelling & tilting mirrors. n & n1=rollers of mirror tilt arm bearing on cam profile o=cam surface for mirror swivel. p=cam surface for mirror tilt

Fig.5 OPTICAL CONFIGURATION EMPLOYING BRITISH PATENT 152,347 TECHNOLOGY

Cams machined on the static outer drum, (at o and p), in the figure, cause rollers mounted on lever arms of the mirror drum to tilt the mirrors in any direction.

However a second Mechau patent, German Patent 371,275, describing a totally different mechanical principle for tilting the mirrors was patented on October 11th 1921 though not published until March 13th 1923. The drawings accompanying this patent are shown in Fig.6.

Schnitt A-B



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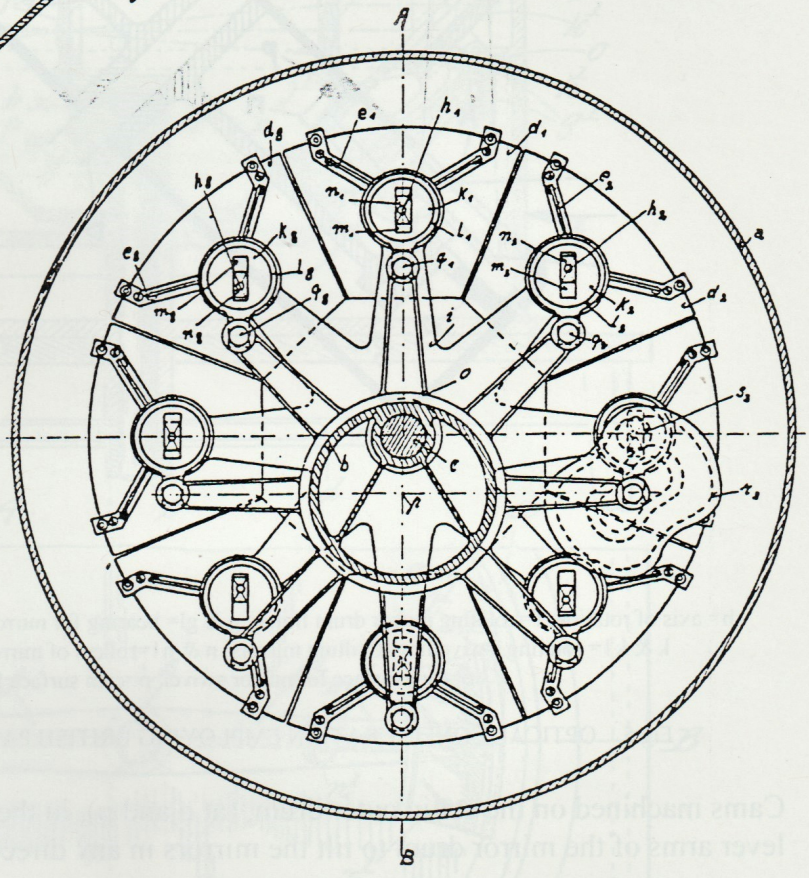
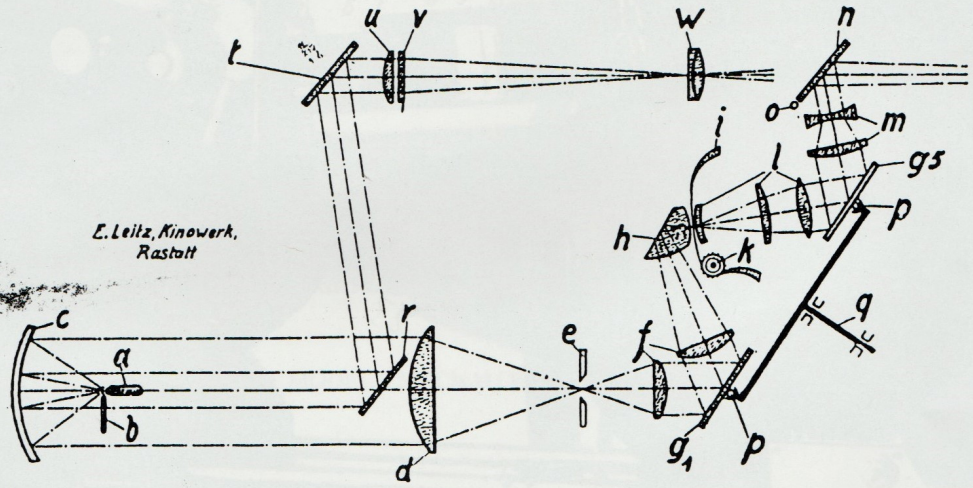


Fig 6a & 6b MIRROR TILTING MECHANISM OF GERMAN PATENT 371.275

Here the variable mirror tilting is achieved by partial rotation and by levers supporting the mirrors which are mounted on pivots. Movement of the mirrors is actuated by eccentric rotation of the circular bearings on which they are mounted.

It is not known to the writer which of the two systems, or indeed variations of these, was employed in commercial manufacture. However I believe the rotary eccentric mechanism of German Patent 371,275 was the mechanism favoured. This is because a very extensive and detailed mathematical analysis of the optical and mechanical design theory behind the Mechau was published in 1928 by Bermester & Mechau (8), as a communication from the Leitz Kinowerk organisation in Rastatt. It may well be that Model 3 Mechau was based on this mechanism right from the start. It will be interesting to have the true facts revealed. Whatever the internal drum mechanism, the schematic diagram of Fig.7 after Thun (17), reflects the general layout of practical Mechau/Arcadias.



c=picture frame mask. g1 & g5=tilting mirror segements. i=film. k=film transport sprocket. m=projection lens. p=mirror pivot. q=rotating mirror drum and axle. r=mirror for slide projection

Fig.7 MECHAU PROJECTOR - OPTICAL CONFIGURATION (MODEL 3 ON)

This appears to be the configuration observed in most published photographs (Figs. 8, 9, 10), with the projected image emerging from the top of the inclined static drum at the Right hand Side of the machine. A number of minor variants of this design are visible in the photographs. Earlier variants have separate 'top' and 'bottom' horizontal spool boxes while a 1928 photographs of Model 4, Fig.10, has a single box for both spools.

Significant improvements which were made over the years in both mechanical and optical departments, may not visible externally. We shall refer to some of these later.

3. NUMBER OF ROTATING MIRRORS IN MIRROR DRUM

It has been difficult from the United Kingdom press to establish precisely how many mirrors were employed in the Mechau. Figures from 8 to 64 have been mentioned (7, 10). One can make an educated guess by considering the practical problems. To space 64 mirrors around a

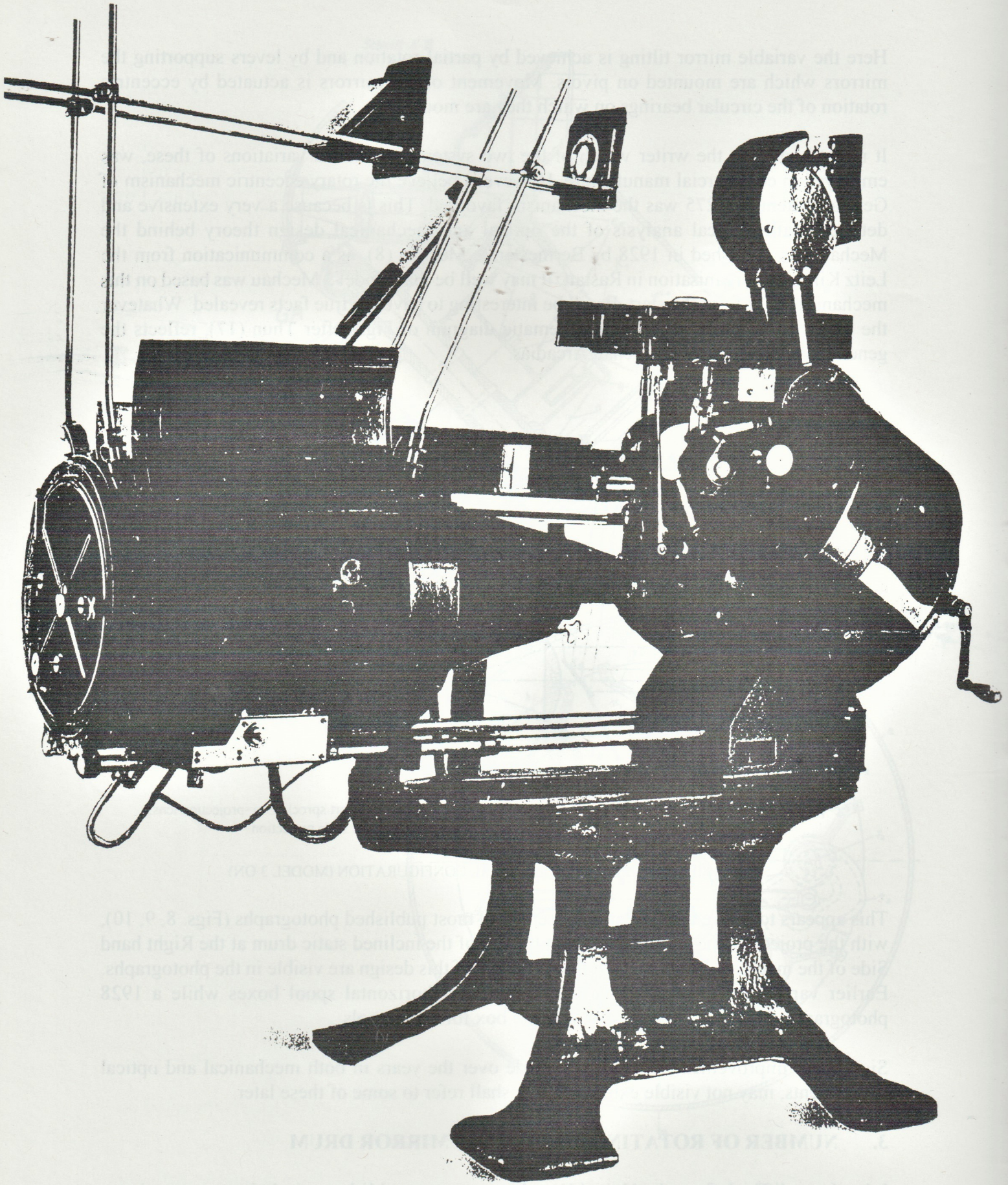


Figure 8. MODEL 3 MECHAU PROJECTOR (Ristow, Ref. 9)

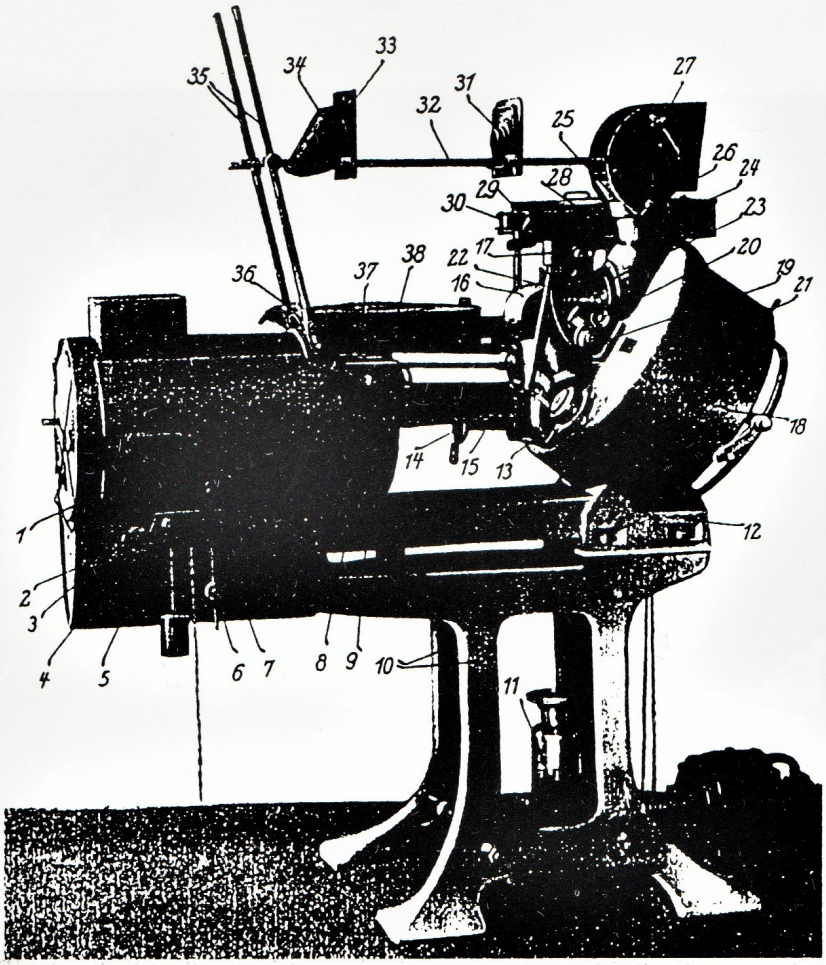


Figure 9. MODEL 3 MECHAU PROJECTOR (after Thun, Ref. 17)

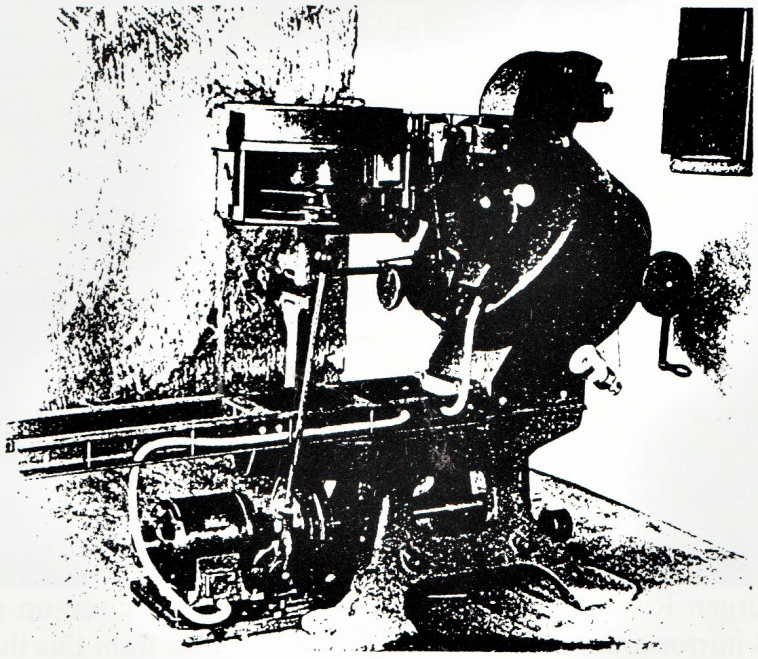


Fig.10a. WITH LAMPHOUSE REMOVED

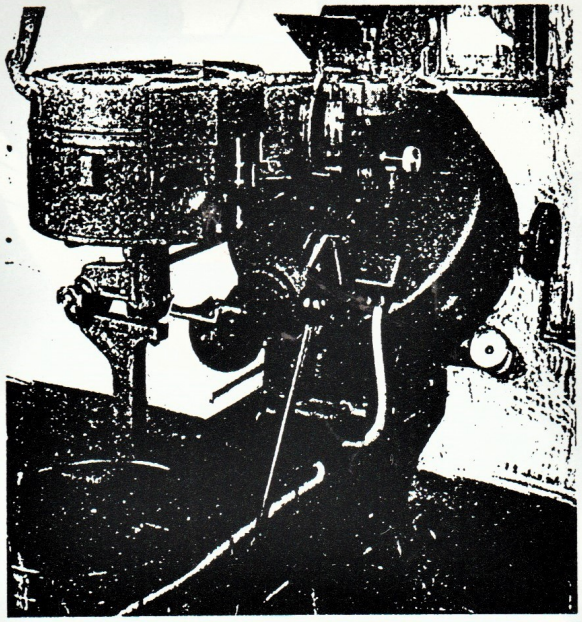


Fig 10b. WITH LAMPHOUSE REMOVED, SHOWING GATE

FIGURE 10. MODEL 4 MECHAU PROJECTOR, 1928

disc, say 24 inches in diameter, would mean they could only be approximately 1.1 inches wide at the periphery. If each of these were to have a Cardan joint and two cam followers the limited working space would present a prodigious mechanical problem. It also sounds like a maintenance nightmare, however good the precision engineering! Eight mirrors are shown in some good published diagrams and the diagram in the key patent British patent 152, 347 suggests not more than 12 mirrors. For the same reason, the rotary eccentric mirror tilting mechanism would also appear to be impracticable with 64 mirrors. Although increasing the number of mirrors would reduce optical deviations, through a reduction in the angles of deflection, a lower number, coupled with the titling mechanism, may be sufficient in practice. It is however quite possible that up to 64 mirrors may have been used in earlier fixed mirror versions.

It is also worth commenting on the speed of rotation of the mirror drum as this has a bearing on the number of mirrors. At the silent film speed of 16fps. eight mirrors would require the drum to rotate at 2 revs per second, i.e. 120rpm. which appears reasonable. With 64 mirrors the speed would only be 15rpm. which is very slow and certainly the sprocket/worm drive, film transport system shown in Fig.3 would not be capable of pulling the film through the gate at a fast enough speed. The sprocket spindle would require high ratio gearing to attain correct speed. This could raise backlash and therefore film steadiness problems. So here again is evidence suggesting a lower number of mirrors.

It was only in the final drafting of this paper that the definitive answer appeared. My attention was drawn to Jurgen Ristow's book (9) where an excellent close-up photograph of the Mechau Model 3 mirror drum appears, see Fig. 11. It is clear from this that 24 mirrors were employed. Even with this reduced number, servicing the tilting mechanisms must have presented formidable problems.

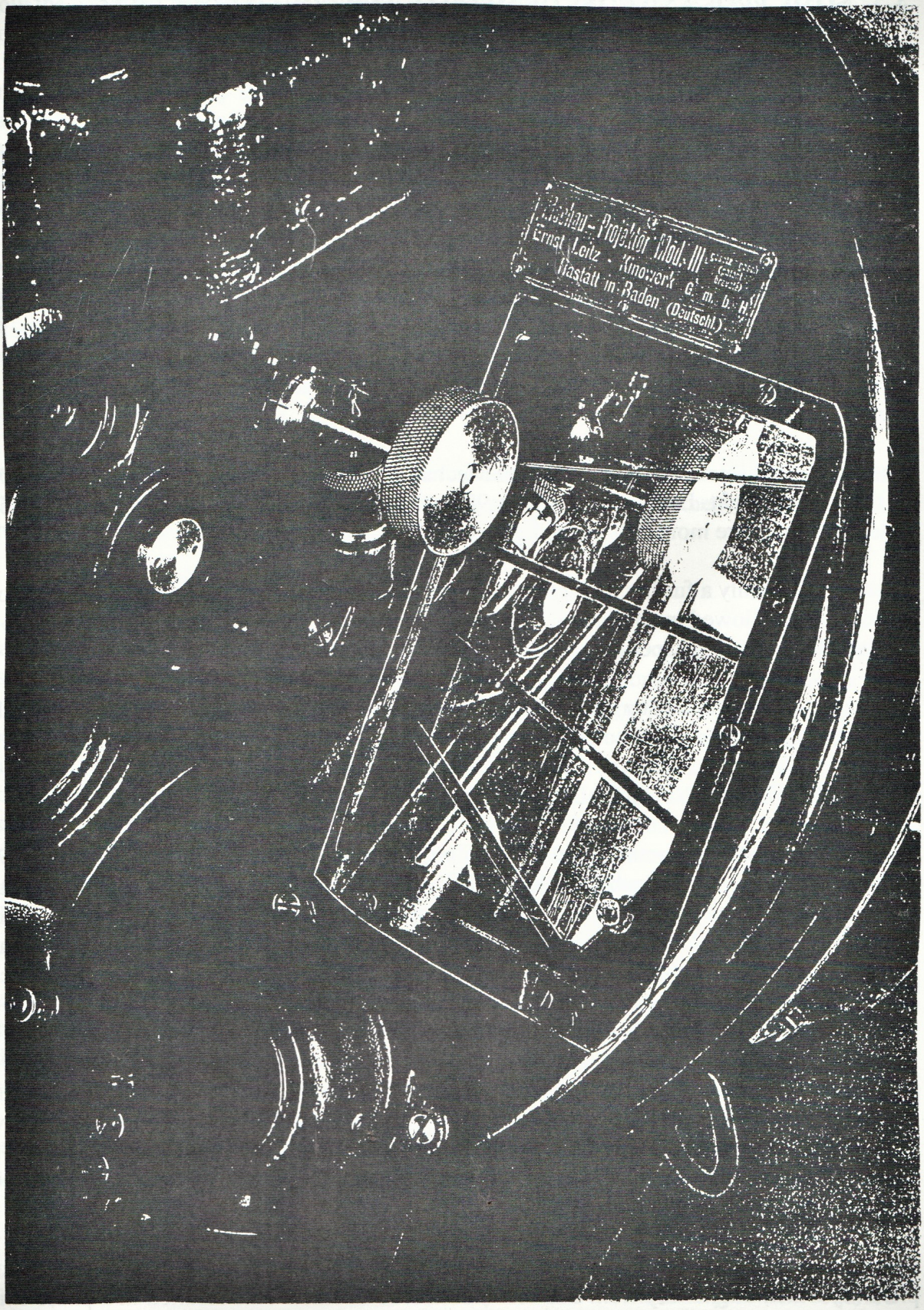


Figure 11. MECHAU MODEL 3 PROJECTOR, CLOSE-UP OF MIRROR DRUM

4. SOME PROS AND CONS OF MECHAU AND CONTINUOUS FILM TRANSPORT PROJECTORS

a) SCREEN ILLUMINATION

Potentially greater screen illumination (50%) has been claimed for continuous systems. This arises because there is no 'shut-off' period, the film being continuously illuminated. With a conventional intermittent, the screen is dark during the picture shift. However, with some optical intermittent systems this is negated by the fact that two film frames have to be illuminate as one image wipes from frame to frame. This, at a stroke, more than halves the screen illumination. However, as had been pointed out by Leventhal (11) only one frame is illuminated in the Mechau projector. The arc spot, instead of remaining still moves with the frame being illuminated. Under these conditions the light efficiency is roughly the same as in conventional projection, but screen illumination rises because there is no dark period due to shutter cut-off.

An unavoidable source of light loss in the Mechau arises because mirrors do not reflect 100% of the incident light. Even if they reflect 98%, this means that with four reflecting surfaces (and often there are more) 8% of the light is lost.

There is potentially a further restriction in screen illumination due to the tortuous and narrow optical paths followed in continuous film transport systems. This can place severe restrictions on the effective optical aperture of the overall projection lens system.

It is to the credit of the Leitz optical team that the pros appear to out-number the cons as the literature refers to lower arc currents with the Mechau for a given screen illumination (13).

b) DEFINITION AND STEADINESS

With many multiple reflections and the possibility of double images due to reflections from the front and back mirror surfaces there were many problems to be overcome. In the later Mechau machines, ingenicus optical computation arrangements ensured convergence of the double-images caused by the mirrors which were 10mm thick (11). Definition equal to that from surface silvered mirrors was claimed. It goes almost without saying that the optical precision required is of a very high order, as is the precision engineering necessary to maintain the correct optical alignments over long periods of time.

It should also be noted that a curved film gate was employed in the Mechau. This was not just on the grounds of low frictional wear on the film. It was an optical necessity, as the objective lens system computed had a spherical field of focus. The film curvature was therefore designed to match the lens optics. An effective objective aperture of f.2.1 was achieved, which was wide for the time.

One source of picture unsteadiness was identified as due to a variation in film perforation pitch (8) which might vary from one manufacturer to another. This resulted in a phase shift between picture frame and film sprocket/mirror motion, manifested as picture vibration. In the Model 3 mechanisms employing the rotary eccentric mirror design the phasing between the film movement and mirror position could be varied within small limits. This was achieved by raising or lowering the eccentric on the main hub of the rotating mirror assembly. A boss

below the eccentric hub had a screw thread which engaged with a worm gear on the end of a lever arm, called the control arm. This was moved until picture jitter was at a minimum.

Continuous, evolutionary development of the Mechau achieved a high degree of picture steadiness. An interesting paper from Leitz (14) in 1928 relates how the last vestiges of picture unsteadiness were only eliminated by attention to the mechanics of film transport rather than to the optical dynamics. Decreasing the diameter of the film traction sprocket (combined with improvements in the gearing necessary to increase speed) further reduced unsteadiness. However, the biggest improvement resulted from a reduction in the distance between the picture gate and traction sprocket, from 110mm (in older Mechau machines) to only 45mm. It is stated that the reduction in the last traces of unsteadiness was astonishing. The culprit was attributed to defective film perforations. This lesson has also been applied of course to intermittent machine design.

c) FILM WEAR AND TEAR

Lower film wear is certainly likely with no intermittent. However the person who gains is the film renter and the cinema owner is unlikely to pay premiums on equipment purchase unless he himself can see a cost benefit.

d) ADAPTABILITY FOR SOUND

It has been claimed that the silent Arcadia machines could not be converted to sound. Whilst it is true that local conversion of existing machines presents some problems due to the unusual film path geometry compared with conventional vertical projectors, it can be and was done, quite successfully, as Barry reports (15). Certainly there would be no intrinsic difficulty in incorporating a sound head at the design stage. One would expect that all AEG manufactured Mechau's, post 1928, to have incorporated integral sound heads. Mr.Ken Wardle, former manager of the Globe Cinema in Cardiff, told me that, whilst serving in the Army in North Africa he found himself running a former German camp cinema equipped with Arcadias. he recalled running "Annie Get Your Gun" - not a bundle of fun without sound!.

e) OVERALL COMMENT

While there are reports of poor focus and a proneness of the prism directing the light path on to the picture gate, to crack (16) it seems likely that, at their best, the later Mechau machines could approach the definition and contrast achieved with direct image projection. Certainly those who have operated a Mechau pay tribute to the almost miraculous, effortless wiping of one frame to the next from rest to full speed, flickerless from 4 frames/sec upwards. On the other side of the coin it has been remarked that, wonderful as its operation was, it was virtually impossible to re-adjust a Mechau if any of the mirrors came off their axis (17).

e) COMMERCIAL VIABILITY

It is here that the Mechau fell down. The level of optical and mechanical precision required does not come cheap. A cost of around £1000 per machine has been mentioned (16) at a time when the going rate for a conventional Maltese Cross machine would have been under £500. To the exhibitor, capital cost is everything and must be justified. The benefits to him were small, possibly a small reduction in power costs if claims of greater optical efficiency were

substantiated. So it is not surprising that the Arcadia made no headway in the United Kingdom.

Mechau projectors did however play a significant role in the early days of television. Baird used one in the late 20's to televise films with a mechanical flying spot scanner. In 1938 the BBC used two of these machines to televise films for the 405 line TV service, cathode ray tube scanning of the continuous moving film image being employed (12). Modified Mechau's were employed post-war, in the Lime Grove telecine operations. One of the attractions being that the machine could display a still 35mm frame and when set in motion would display from rest, a steady moving picture over a wide range of speeds. Life however has moved on and today we have purpose-made self-contained film scanners for film televising.

5. CONCLUSIONS

One must conclude that the Mechau/Arcadia was a gallant and brilliant failure. It pushed forward the frontiers of projection technology and established a technically viable alternative to the ubiquitous Maltese Cross intermittent. But at a cost which was unsustainable in the major markets. Its lingering, long life in Germany may be partly a matter of technical pride and a degree of subsidy by the AEG/Leitz organisations.

However it seems to the writer that there are niche markets where the Arcadia, even today, could justify its cost. One of these is in film archives and similar organisations where rare prints need occasionally to be screened with minimum risk of wear. Ironically, most individual editing/viewing machines today use optical intermittents and continuously moving film to minimise film wear and damage.

I hope that arising out of these comments, someone somewhere will confirm where an original Mechau can still be seen. In 1981 the BBC (18) was said to have a Mechau around in store. A working copy is said to be in the Deutsches Filmmuseum in Frankfurt, but I have no details. So let us hope that the last vestiges of Emil Mechau's pioneering work have not vanished forever.

ACKNOWLEDGEMENTS

We are indebted to Kevin Carroll whose diligent researches into the literature on Mechau's work provided the stimulus for this Information Sheet. My thanks are also due to Stephen Herbert, Bill Stephenson and Deac Rossell for additional information. We are indebted to the cited publications by Cornwall and by Ristow for some excellent photographs of the Mechau. To their German publishers, Gerhard Knulle and VEB Photokinoverlag, whom we have unsuccessfully attempted to contact, our thanks.

Dick Hall, June 1995.

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