AERODROME and AIR ROUTE LIGHTING

at

TRADE MARK

1929 to 1944

F. W. Cooper, BSc, C Eng, F, Mech E, FIProd E.

Lighthouse Department
Chance Brothers Limited

1979

Preface

F. W. Cooper, who was known as Wally, wrote this document in 1979. Wally produced a hand written two-part manuscript that was never published. The first part covered lighthouses and the second covered aerodrome lighting. The manuscript was hand printed in a tiny size and liberally illustrated with hand created drawings and tables. Mr. Cooper apparently gave a Xerox copy to one of his friends. That copy was, many years later, sent to a gentleman in Canada who was writing a story about lighthouse clockworks. I read that story and noted the reference to Mr. Cooper's manuscript. I contacted the man in Canada and was sent the entire manuscript. I have a strong feeling that this manuscript should not be lost to the lighthouse community. The following is a typed version of the original Aerodrome Lighting manuscript with a few slight modifications for clarity. I have added several pages at the end with photographs of the various aerodrome equipment described in the document.

Thomas A. Tag

F. W. Cooper's description of the firm of Chance Brothers and of himself

I am still being asked how any firm could keep in business if it only made lighthouses, incidentally something that occurred only in my apprenticeship – 1924 to 1929. The lighthouse department founded in 1850 was, however, very independent of the glass works although I do not doubt it was a financial burden in the early 1930s. Chance Brothers was one of but five companies in the world making lighthouses the others being in North America, Germany, France and Sweden.

In the early 1930s the large electric lamp became available for aerodrome lighting and Chances bought up the Austinlite Co. of Banbury, makers of lighting sets for homes. A new and large electrical shop was built to make lighting sets for marine and aero lights, emergency sets for railway signaling, traffic lights, Post Office repeaters, submersible pumps, switches, clutches, etc. Aero equipment included floodlights, beacons, wind indicators, runway and obstruction lights, etc.

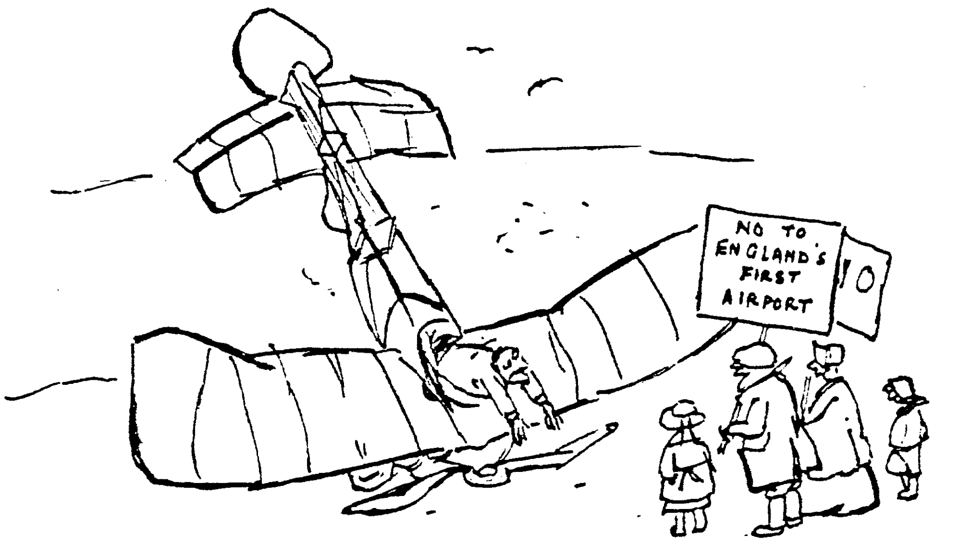
The lighthouse department also had several large machine tools, which we kept busy doing machining for other companies. These were kept very busy in World War II. 1937 saw a very large program of Army searchlights, sound locators, predictors; of Air Force, beacons and floodlights with mobile generating sets, etc; and for the Navy, RADAR nacelles, fire switches and lights. Personnel rose from, roughly, 250 to 650 and the following new shops were built – welding, plating, testing, precision assembly, a new drawing office, etc. We also acquired a disused tram shed on the Birmingham – Oldbury Road for truck-mounted equipment.

The staff included one director and one works manager with four foremen (fitting, machining, glass grinding and electrical). The several charge-hands led the "gangs" for producing optics, pedestals, lanterns and tower fitting, flashers and equipment, fog signals, switch-gear, generating sets, etc., and, of course, the sections supplying the components: machine shop, inspection, stores, patterns, smithing, welding, etc, etc. There were also the drawing offices, which covered electrical and tooling, jigs, etc.

The lighthouse department was thus able to broaden its products and I well enjoyed my six years as Assistant Works Manager coupled with Chief Inspector. I finished as Chief Mechanical Engineer. My external London degree enabled me to do some engineering teaching at the Chance Technical College (named after Sir Hugh Chance, Chairman of Governors) and in 1944, I followed Jack Dodds into pastures new, and became an Assistant Lecturer at the College. After a short spell at the Birmingham College of Technology I returned to Smethwick as Head of Department (everything but Commercial Management) and for my last five years, Principal. Much building took place in these years. In 1957, I managed to combine my academic knowledge with industrial experience in becoming Assistant Secretary (technical and education) at the Institution of Production Engineers. This happily included visits to many European countries and to India, Australia, South Africa, Canada, Singapore, U.S.A., and Peru. I retired after 49 ½ years work in 1973.

CONTENTS

Chapters



Acknowledgements:

I am much indebted to:
Chance Brothers: for booklet “Aerodrome and Air Route Lighting Equipment.”
Dr. W. M. Hampton for “The Photometry of Projectors” given to the Illuminating Engineering Society and his paper given to the Physical Society in 1923.

Illustrations:

To Chance Brothers for the above booklet and, I believe, to Purch and F. Folkes for drawing above.
Possibly again to the W.O. for the photograph of the 90cm Searchlight; To the A.M. for the Aerial Lighthouse.

1 Introduction

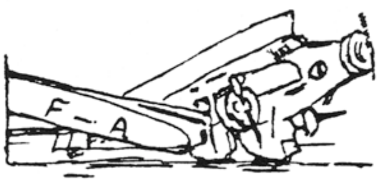
By the mid – 1930's more than 100 million miles were being flown annually on regularly operated air routes. Civil aviation – for first class travel, for the transport of freight and for carriage of mail – had, arrived and a new industry founded.

One of the many problems presented by this upsurge of flying activity was the necessity to ensure safe night flying. Aerodromes (and largely these were just a fairly large piece of meadow land, reasonably flat and fairly close to a large city) required correct illumination of the landing area and routes between such aerodromes required demarcation by means of light beacons.

And what better than the Lighthouse Department of Chance Brothers Ltd. of Smethwick, with their long experience of Marine Lighting, to do this!

Simplicity itself – or nearly so!

Having read my "Twenty Years in Lighthouses" you can visualize a 3rd order dioptric fixed lens, covering 180º in plan with a 10,000 W or 10 KW electric lamp at its focus. Mount this on the edge of the landing area, switch on and the area will be splendidly illuminated and ample for the planes of those days to make a safe landing. Such was the first floodlight!



The Golden Clipper Service, London to Paris. Air France, Wibault-Penhoet 282-T-12 Weight 13725 lb. three 400hp engines with a cruising speed of 140 mph. Ten passengers, three crew.
Lovely!

(The first commercial air service England to France was in August 1919)

Now for the Beacons. Take this time a 4th order lens with the other 180 screened off and with a 5 KW lamp. Tilt the beam a few degrees above the horizontal, revolve it, say at 12 rpm and you have a flashing beacon that can be seen by the pilot many miles away! Level it up, stop it revolving and you have a floodlight – wonderful!

Alternatively, take a 24" diameter mirror with a 1½ KW lamp, with its axis say, 2º above the horizontal – and revolve it. Result a flashing beacon of 1.1 million candlepower.

Other equipment deemed necessary by the Air Ministry for a Class 'A' aerodrome included boundary and obstruction lights, a lighted wind direction indicator and flares (in case of emergency). The Department could also throw in an illuminated desk for the flight controller and also generating sets either main or standby. Oh and I forgot the Air Ministry demanded on the Aldis Lamp so that the flight controller could have a chat, in morse, with the approaching pilot or the soon departing pilot!

So for quite a few years Aerial Lighting occupied a fair proportion of my time at Chances and many interesting problems arose. But such has been the explosion in technology that all is now forgotten. Maybe in some quiet spot abroad a Chance Beacon or Floodlight may still be working – or perhaps in an industrial museum. Up to a few years back the 'gough' Beacon was winking away at Belfast Airport and mine at Cromwell R.A.F. College, still welcoming home the errant cadet.

So very briefly this is the story of the work of the few Lighting Engineers, in Civil Aviation, in the pioneering days. Thank goodness my limited imagination did not foresee the many-headed monsters we now call international Airports!

2 Floodlights: Fixed; Shadow Bar and Mobile

Fixed: "No. 1" After 50 years details are hazy and the exact date escapes me – possibly the end of the 1920s or very early 1930s! The lens was fixed dioptric, 500 mm focal distance, about 3' 3" high and covering 180º in plan. It was mounted in a cylindrical housing with a conical roof complete with a large ventilator – and leveled with three screw jacks.

No. One Floodlight.

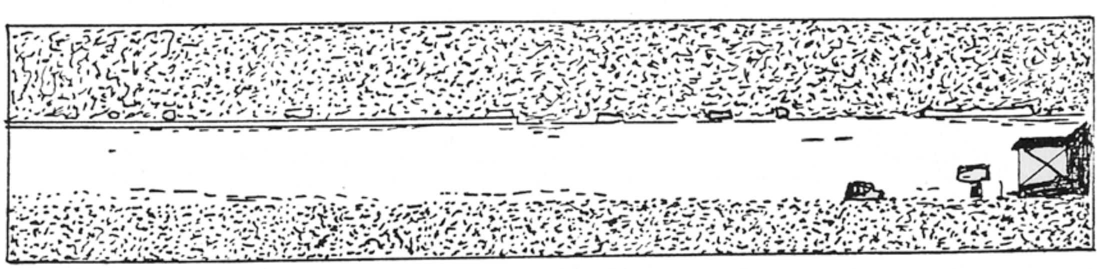
The lamp must have been a very early type, chiefly for the film industry. It was a giant electric lamp, easily 30" high with a 15" or so bulb, consuming 10,000 watts or 10 KW.

The floodlight was set-up behind the Lighthouse Shop to illuminate the sports ground. Having read my "Twenty Years in Lighthouses" you will know that it threw a thin horizontal fan beam across the ground.

[It was so impressive that Major Gubbins, our then Director (a kindly man whom I kept in contact with, long after leaving Chances) decided to bring along two friends to see it. It must suffice you that one was a V.I.P. the other very much more so. Being June we fixed mid night for lighting up but one a.m. went and still no party! We were about to pack up when our gatekeeper flung wide the gates and a very nice car swept in. We swept up to the car and then got tangled up a bit. On what followed we will draw a curtain – but not over the floodlight. Again suffice to say, the incident preceded the BBC's famous "The Fleet's lit up".

Prior to this we suffered an amazing misfortune. The lamp arrived in a large open crate, floating on tapes, rubber thongs, springs etc. The day came when the fitters required it so it was unpacked in the stores (the first error) and given to the assistant storekeeper, a disabled man from World War 1 who had a wooden leg, to take down to the fitters at the far end of the main shop (the second error).

God bless our crane slinger had loaded a large casting heavily in the main gangway and left a piece of floor boarding sticking up (third error). Guess the rest! Next! The storekeeper snagged it with his wooden leg and down he went, clutching the lamp to his bosom. It is recorded that he slowly rose and then subsided onto a bed of broken glass and shattered filaments! Fortunately, he was not hurt except to fillings. We only brightened up when Jack Dodd's notes to the two foremen concerned, did the rounds. One was told not to use one-legged helpers; the other what to do with glassed floorboards.



Heston Airport Floodlighted for night flying by one of the three 'Chance' 4½ KW Floodlights.

The 4½ KW Reflector Floodlight (see Fig. 1)

The three mirror units each have a 1½ KW lamp at the focus of a spherical (in plan) - parabolic (vertically) mirror consisting of six vacuum molded sections. The overall dimension of each mirror set is about 2' 9" wide, 3' 6" high and covering 120º in plan. From mirror axis to ground is 8 ft. a suitable figure for most aerodromes. In front of each lamp is a pair of small de-centered mirrors, which well of course increase the candlepower (to a total of 1.25 million) and obviate stray light.

Fig. 2 shows a range diagram for illuminations of 0.15 and 0.2 ft candles and the sketch at the bottom of Page 2 shows how effective the 120º fan beam is. The housing shown is of 'laminoid' and two ventilators and an obstruction light are fitted. A cheaper housing was also offered in steel sheet.

Depending on the size and shape at the landing area from three to six of these floodlights are used around the boundary. A permanent ring cable with switching facilities will enable the flight controller to choose one or two floodlights so that the pilot has the light behind him when landing into the wind.

If a lamp blows at this critical time the other two mirror units remain lit. Three units also suit a 3-phase supply.

3 Shadow Bar

1 S. B. Vertical Plates
2 Linking Bar
3 Hand Wheel
4 Pivot Supports
5 Balance Weights
6 Housing
7 6 (six) Mirrors
8 De-centered Mirrors

Shadow Bars: if a single 10 KW dioptric or a single triple 4½ KW light is used the occasion will arise – with the wind coming from the floodlight when the pilot might be "blinded" by the beam. Using the shadow bar, which is essentially just a vertical plate/s which can be moved by hand around the light unit/s by an operator just behind the floodlight and just above the beam, the landing plane is thus kept in a lane of shadow of spread about 7º in plan.

The plan view in Fig. 1 shows 'sketchily" the necessary three bars – coupled together, with an outer hand wheel – for the 4½ KW floodlight. False shadows can be obviated, with a 120º mirror, if each bar works inside its own fan beam.

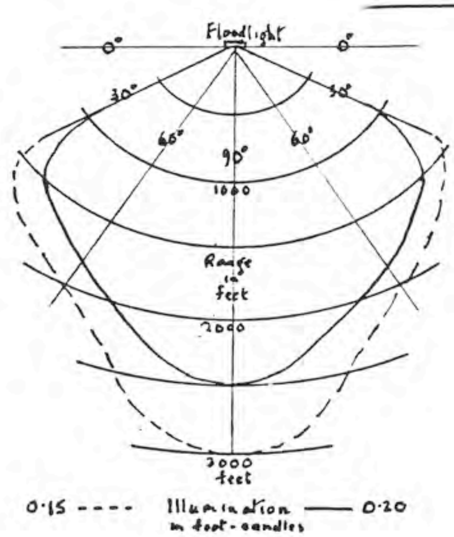


Fig. 2

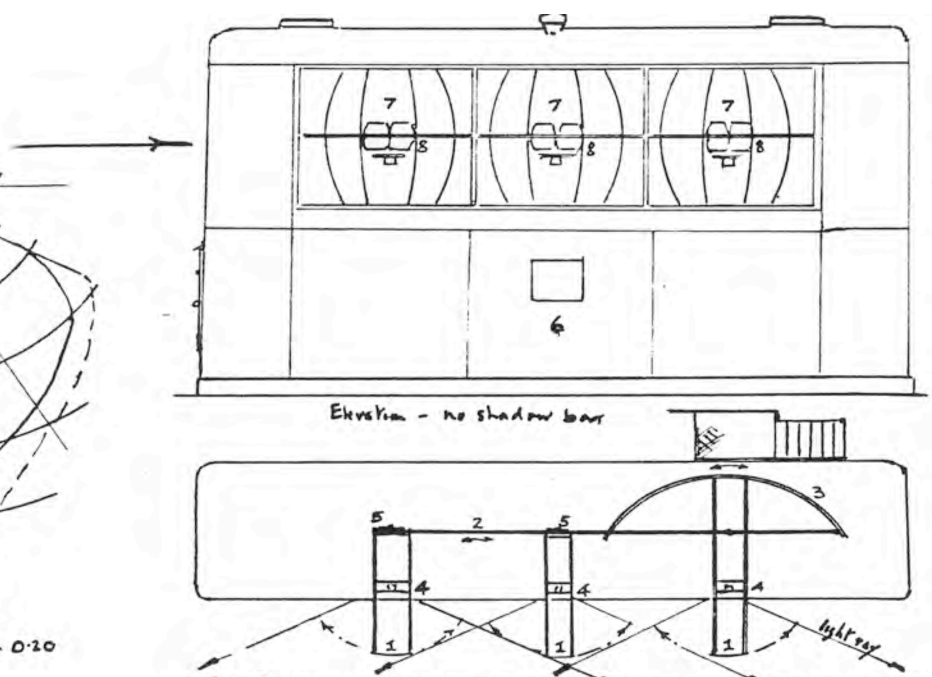
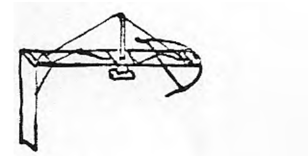


Fig 1 4½ KW Reflector Floodlight with 3 Shadow Bar – Plan.

Shadow Bars – a few details:

i) As shown on plan view of Fig. 1, page 3. The two outer bars have vertical plates, 66” high by 16¾ “ wide, at a radius of 4’ 8” from its pivot. Since allowance has been made on each side for filament dimensions, the plate will give a dark shadow of 14” spread. A hand wheel is added to the left-hand tubular structure, incidentally obviating a balance weight, whereas the right hand requires 50 lb.



Single shadow bar

The center bar is but 13½” wide, meaning no side corrections. This is satisfactory since it but reinforces the center of the “triple shadow lane”. A balance weight of 70 lb is required. The linking bar parallels the three frames over a total movement of 120º of the hand wheel.

ii) A single shadow supplied, among others, to Karachi and Calshot: this is for the 10 KW dioptric floodlight. The single vertical plate was 54” high by 15” wide at a radius of 6’ 6”. Applying correction for filament width this is seen to be a 10° spread shadow bar. A balance weight of 54 lb was required at 2’ 6” radius. As shown in the sketch a stay wire takes the end droop out of the tubular frame.

The Mobile 5 KW Floodlight – Beacon.

This was quite a success story and I name just a few of the places where the dual purpose – either a mobile (to suit the wind direction) floodlight or a guiding beacon – proved a good investment: British Air ministry for the England-India (middle east section) air route etc. etc.; Crown Agents for the Colonies – includes Salisbury, Rhodesia; Nibeya, Tanganyika; Penang; Canada; Australia.

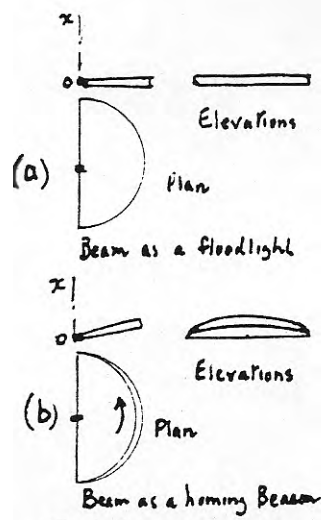


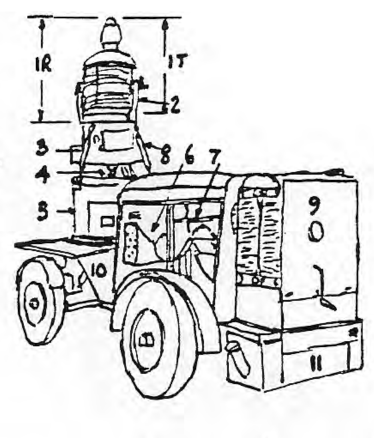
Fig 3 Beams.

The lens was a 4th order (250 mm focal distance) dioptric ‘fixed’ type subtending 180º in plan, with a 5 KW lamp and a pair of de-centered mirrors. When used as a floodlight the beam is as a thin fan (covering 180º in plan) horizontal or parallel with the ground. When tilted for use as a beacon this thin fan (for example, raised 10º above the horizontal) rotates about the vertical axis. You may like to compare the unusual shape of this beam with the ideal pencil beam of uniform “thickness” given by the 1½ KW dioptric airway beacon shown on Page 6. Certainly one would never use the Floodlight Beacon as a route beacon but merely as a homing beacon actually on the aerodrome. I see no reason, for tilts from say 2º to 20º, to worry about the shape of the beam and, for example, some slight difference in duration of the flash dependent on the height of approach of the plane. Fig. 3 refers.

The method of tilting the optic is clearly shown in Fig. 4 and the three turnbuckles with the ball and socket, resting on a resilient mounting, give a ready means of leveling the optic when used as beacon floodlight. Assembled on a torsion bar or leaf spring trailer the unit can be towed to any point on the boundary of the landing area at the discretion of the flight controller.

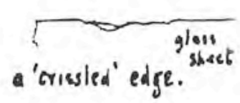
I will deal with the generating set later under the “RAF Aerial Lighthouse”, see page 11. Except for the electrical output (a 3 KW lamp as against 5 KW) they are much the same. Since many of the floodlight-beacons worked in temperatures of 100º to 130º F, and often in dust storms, the task of keeping the engine and generator reasonably cool was quite a job!

Parts :
1R . optic : revolving portion
1T . optic : tilting portion
2 Trunnion arms
3 Housing for driving motor etc
4 Ball and socket mounting
5 Cabinet with spare lamp
6 Generator } with switch-board
7 Engine
8 Turnbuckles
9 Radiator and fan
10 Trailer
11 Fuel tank.



shown in working condition with generator doors removed
Mobile 5KW dioptric Floodlight-Beacon
Fig. 4.

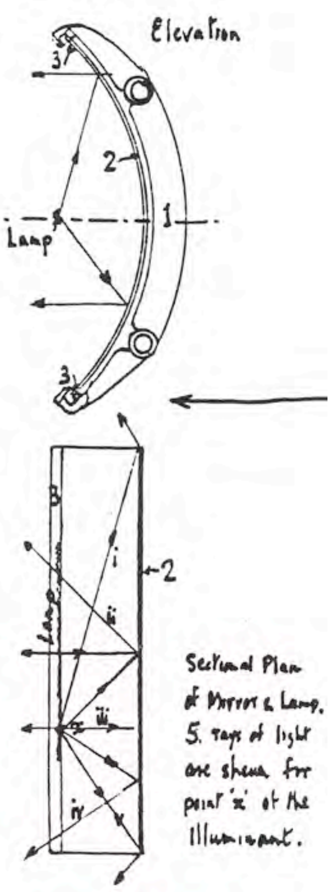
Our first attempt to meet desert conditions – and we were using Ford four cylinder engines – was to use a Ford (tractor) fan and radiator. The first snag was that the engine got away so quickly that it almost left the large fan standing. Naturally the belt, engine to fan, slipped badly and being a leather link type it just disintegrated into a powder! Phil Robinson, the electrical section foreman, quite disgusted and telling me what should be the fate of all designers, pointed at the fan belt and promptly lost the tip (a very small bit fortunately) of his finger. The second snag was that the new radiator and fan did not cool the engine sufficiently for desert temperatures. So Jack Dodds ordered me to get two long radiators and an axial/radial fan 'Sitocco' type with a new drive from the engine to the fan and also to get the engine and generator partitioned off effectively. The result was wonderful. The engine nearly developed a coating of frost, whilst the poor isolated generator dropped grease, and was hot enough to grill a steak on. So away with the partition and all was well – indeed. Fig. 4 clearly shows this cooling system.



We also persuaded the customers, having removed the generator set doors, not to fill in the big holes left with long frames of fine gauge, but to put filters on the generator air intake (again see Fig. 4) and to have a good size one on the air intake to the engine. Let me add hastily that when the trailer was being towed the four doors were in position.

From Desert to the Arctic Circle, or +130º F to - 40º F.

Fig. 5



HM Government requisitioned 20 of these floodlight-beacons for the Russian Front (WWII). A precondition was to find a cold chamber capable of -40º and, surprisingly, one was on hand at Lucas Ltd. in Birmingham. Starting the engine was no trouble, since an excellent little device attached to the carburetor was already marketed. One just popped into this device a phial of ether, and when the engine turned, it knocked a plunger down which smashed the phial. So for a few vital seconds ether vapor preceded the petrol vapor and the engine was away. This setup was negated by certain vital parts, made of the then much used natural rubber, which became brittle and useless. And what a large number of parts, here and there, were made of rubber. So over to synthetic rubber and that wasn't easy. Woe and woe, the 20 never reached Russia! The convoy in which they were shipped was practically destroyed by the Germans. We tried again later! Judge the success of this floodlight-beacon by the number of WWII airmen who have told me: yes, I remember well the 'Chance Light.'

A Plano-parabolic Mirror Unit.

The search was always on for something better than the vacuum-formed mirror, or cheaper than the dioptric light, for floodlights. Fig. 5 shows a solution made possible when we purchased (largely I think to machine the complex shapes of molds for glass making for the Glass works), a machine tool with a copying device. Using this we were able to machine the formers (1) to an accurate parabolic curve.

Three formers made an excellent frame for the thin glass mirror (2) (made in the flat not curved) and all that was then required were two pressure bars (3) to push the mirror into the frame until it fitted snugly into the formers. Metal bars invariably 'crissled' the edge of the mirror and led to quick failure. Finally, we used plastic impregnated wood, which when held very rigid, had a surface soft enough to prevent 'crissling.' With a tubular lamp in each, the mirror units made a very nice floodlight.

3 Beacons - Dioptric and Mirror

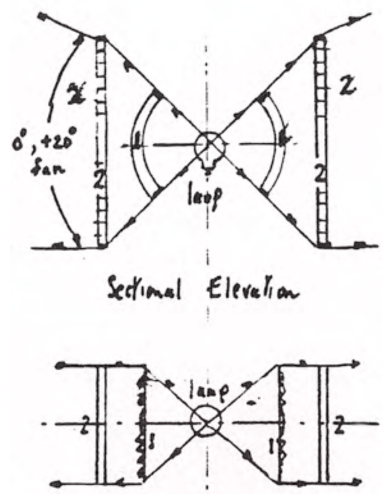
Dioptric: 1½ KW Airway Beacon

Harold Gough, then Optic Section leader in the Drawing Office, in cooperation with Dr. Hampton, designed a neat optic using a twin (two lenses side by side) lens system, which gave two (at 180º in plan) rectangular sectioned, pencil beams between the angles of 0º and + 20º above the horizontal.

The optic was rotated at 6 rpm (1 revolution in 10 sec.) so giving a flash every 5 seconds and with a 1½ KW electric lamp had a stationary candle power of 2 million and a constant duration of flash of 0.2 seconds. It is tempting to give ranges for such a powerful beacon. Reducing the 2 million candlepower to an apparent intensity gives 1.14 million candlepower, both at +1° – (see Fig. 6) and 500,000 candlepower, at +3º to 285,000 candlepower. With a transmission factor of 0.75 and no cloud layer up to 8,000 ft. luminous ranges of 28 and 22 nautical miles could be expected. At extreme luminous ranges the height of the plane would be very roughly 3,500 and 7,500 ft. I think you will agree that Chances are correct in not quoting ranges!

Fig. 7 shows diagrammatically the optic system. The partial drum lens (1) is of the 5th order or 187.5mm focal distance – and is, uniquely, lying on its side. Thus, in plan, it directs the light into a parallel beam. In the vertical plane it leaves the light rays untouched. Each, outer, diverging panel (2) leaves the light rays untouched in plan but in the vertical plane, the redial light from the drum lens (1) is made much less divergent. As shown in Fig. 7 roughly from 90º fan to a 20º fan. This shaping of a beam in two stages is most interesting.

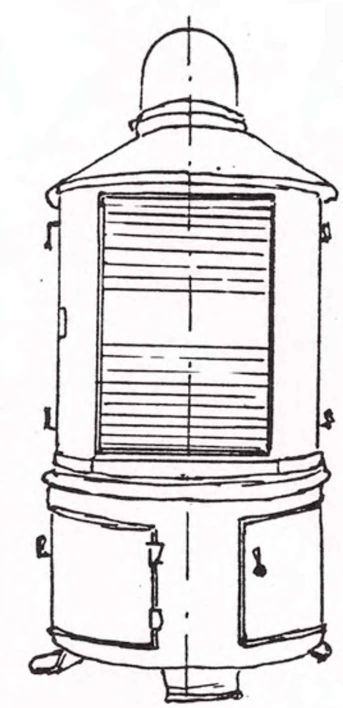
Fig. 8 shows the complete beacon and it remains only to describe:
i) The identification light which is mounted on the roof and consists of a large red glass globe with a 250W electric lamp, fitted internally with screens to give the Morse letter required. The luminous range is about 8 miles.
ii) The lamp changer for the main 1½ KW illuminant is of the tilting type. On failure of the No. 1 lamp, the No. 2 is automatically brought in and lit.



Sectional Plan

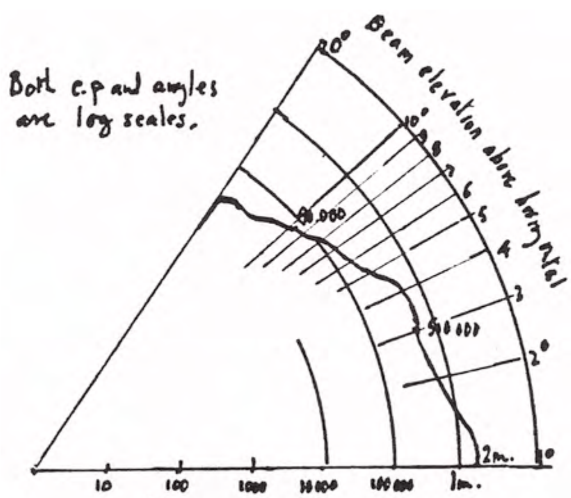
Twin, '2 lens' optic

Fig. 7



1½ KW Dioptric Airway Beacon

Fig. 8



stationary candle power

Fig.6 Vertical light distribution

Focusers were fitted to accurately position the filament relative to the optic.
iii) The lower casing which houses the slip-rings for feeding the main and the identification lamps, also contains the ball bearing ‘pedestal’ on which the optic revolves, and the necessary driving motor and reduction gear with friction ‘clutch’. Further details of the pedestal will be given on pg. 8 when dealing with the 24” Reflecting Beacon.

At the time of our beacon we had an engineer very new. To save costs an existing wooden pattern for the Cast-Iron Turntable, on which the optic in its’ ‘lantern’ was mounted, was with some minor modifications used. It was far to heavy for the job but in those days cast-iron was cheap. The engineer decided to have a direct drive. In the first test the starting switch was closed and with a dreadful ‘wish-ang’ the output shaft sheared off like a carrot, fractional horsepower motors get off the mark very quickly. Second try was to specify a 3½ % nickel steel output shaft for the (non-reversible) reduction gear. Another carrot! Third try was to fit a free wheel to the driving pinion. Alas it never had a chance to freewheel since another output shaft snapped off on starting. In despair the long proud ‘Cooper friction clutch’ was fitted and all was well.

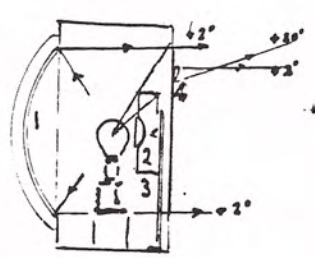
Later we received an order for the 1½ KW Dioptric Beacon for Belfast Airport, the beacon to be mounted on a 100 ft. high openwork tower. This occurred in the short-lived ‘era’ of the chief draftsman of old fame! Catching me in the early period of designing the tower I was asked, “Had I never seen an electric supply grid tower,” yes I had. Even in those 33,000-volt days you couldn’t hide-em! I had also noted how they were loaded and the rather different design when the line turned a corner! So to save £100’s the design was given to one of his cronies – less material of course.

The story now moves to Belfast where Ernie Banalt having completed the erection of the beacon, pressed the (local) starting button (normally the flight controller in the central tower switched it on). In the next second he was hurled into the handrails on the top platform and found himself looking over them (100 feet of nothing) with mercifully, one leg crooked between the hand rails. Having attended to his cuts, bruises – and shock (Irish Whiskey I suspect) the local starting switch was extended to the bottom of the tower and again pressed. The very slender tower twisted nearly 90º at the top and shot back again!!! Tut! Tut!

Now Newton defined “equal and opposite forces” and this can be re-written as “for every torque there is an equal and opposite torque” so if you must start up a long heavy, nearly frictionless, rotating body (the optic, lantern etc.) with a fractional horsepower motor (and I suspect the friction clutch was too ‘tight’) then don’t put it on a slender tower with little torsional strength. Later, when, with the Institution of Production Engineers, I flew in and out of Belfast Airport, usually twice a year, whenever I saw that - tower with four ghastly hawsers extending from the corners of the tower platform and anchored in the ground below, I blushed for “Chances”]

Parts
1 24" Mirror ; 12" focus
2 De-centred mirror
3 Louvre
4 Diverger strip.

Fig. 9



Mirror system for reflector beacon

Reflector or Mirror – 1½ KW 24” Reflector Airway Beacon

The silvered glass mirror (1) (see Fig. 9) is 24” diameter, 5/16” thick, 12” focus and is ground and polished (meaning that it is spherical). At the focal point is a 1½ KW 210V electric lamp. (The 1½ KW dioptric beacon lamp works at 80V). A single focuser is fitted. A vertical standard carries the de-centered mirror (2) and a single louver (3) to stop stray light from getting outside the lantern and from impinging on the diverger strip (4).

An automatic lamp changer brings in the No. 2 lamp when the first lamp fails.

The back of the mirror is protected by a sheet metal dish whilst the front door is of heat resisting glass to which is secured a single strip of diverging “prism”. This spreads about 9% of the light from the mirror up to an angle totaling 20º above the horizontal. The vertical light distribution is shown in Fig. 11 and it will be seen that the peak stationary candlepower is still 2 million, with the fall from around 3º above the horizontal more than for the dioptric beacon.

A comparison between Figs. 7 and 9 shows that if the frequency of the flash is to be kept at once every 5 seconds the speed of rotation must be 12 rpm and not 6 rpm as with the dioptric beacon. The duration of the flash shortens to 0.12 second giving an apparent intensity of 885,000 cp and the peak range, calculated as before, is but 25 nautical miles.

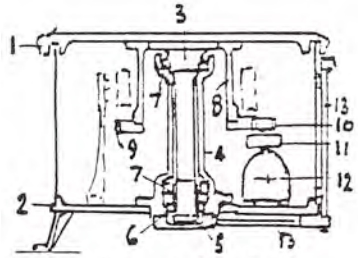
Whilst I think it of little importance, Chances do state that the rather irregular (vertical) cross section of the beam does not give a constant duration of flash. The 5-second interval, of course, remains.

The mirror lantern and the bottom housing for the pedestal, motor drive and slip rings are of mild steel sheet. The lantern can be tilted back to the mean angle of the main beam, +2º or 3º, to suit the local terrain, but is leveled at the top to take the identification light, which is identical with the dioptric beacon. Ample ventilation is provided.

From my notebook I show, in Fig. 10, the ball bearing arrangement for the rotating table carrying the lantern. The slip rings and motor drive are also indicated. You will note the ease of lubrication provided by the external feed pipe, and the prevention of over-filling with lubricating oil.

I have shown in Fig. 12 a bird scare on the red glass dome. It gives the beacon, I fear, a slightly undignified appearance, but for an airport near a coast with the normal hordes of seagulls, it would prevent the dome being fouled all over!

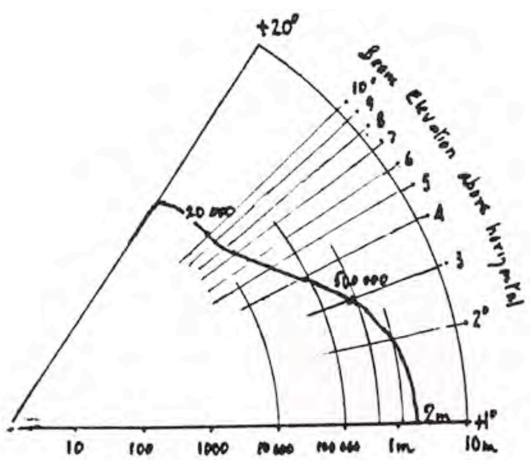
This was a popular beacon: its simple construction in no way spoilt its high performance and the initial cost was at a minimum. Also, I enjoyed designing it.



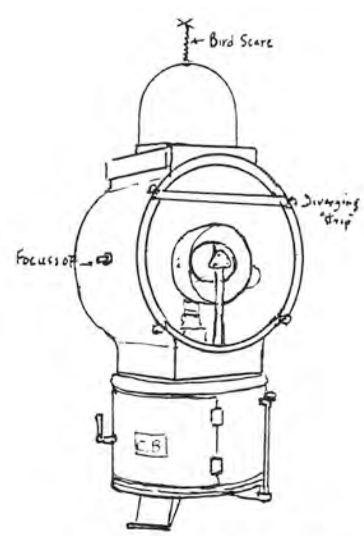
Sectional Elevation
Bottom Housing

Parts
1 Rotating Table for lantern
2 Baseplate
3 Shaft
4 Bearing housing
5 Bearing cap
6 Ball thrust bearing
7 Ball Journal bearings (2)
8 Casing for race wheel and slip rings
9 Race wheel
10 Race wheel pinion
11 Friction drive
12 Motor - reduction gear drive
[ ] slip rings and brushholders
13 Oil filling pipes for lubrication

Fig. 10



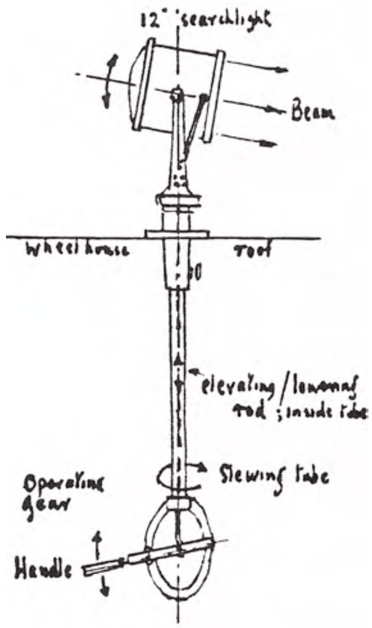
Stationary candle power.
Fig. 11 Vertical light distribution.



1½ KW. 24" Reflecting type Beacon.
Fig. 12

4 Other Beacons: R.A.F. College Cranwell; Chance Neon Lights; Air Ministry, Aerial Lighthouses and a Wind driven Beacon for India

Cranwell: This interesting little reflecting beacon was supplied in 1933. The College main building is very good looking and is a scaled down version of an old masterpiece. I say scaled down, but it was more than enough for me climbing over 100 feet on builders ladders. It was probably Bill Ritchie of fabulous memory who suggested that a wee 12-inch searchlight we had in stock for many years might do the job. Cranwell "had sent us a sketch of the tower turret and dome and it was obvious that even a 12 inch mirror job would only just go through the hole in the concrete dome.



Sketch - elevation of a 12" searchlight for navigating canals

Looking through my sketchbook, prior to writing this, certain features of this mirror light eventually rang a bell. In fact recalling a night voyage through the Corinth Canal clinched it. Bill's light was a searchlight! Just visualize it clamped to the ship's rail and the beam focused on the side of the canal. Saves a lot of bumping in such a narrow canal! I had also abandoned an even smaller edition on the wee boat taking us from Gothenberg to Stockholm on the Gota Canal.

When Chances made this, and it was certainly before I started in 1924, the illuminant was a 'limelight' – a compressed disc of quick lime played on by an oxy - whichever gas came to hand, torch. Now you know what "in the limelight" means or rather that it originated in the theatre! I can finally rectify an omission in my work "Twenty Years in Lighthouses" by recalling that in the mid thirties I designed the operating gear for another canal light, I bet it was in stock - the mirror unit I mean! This time the searchlight was on the roof of the wheelhouse and the sketch herewith shows the one handle for slewing and elevating or lowering the light.

Reverting to Cranwell the snag was that once the light unit was in the turret, replacing a blown electric lamp, cleaning the mirrors, slip rings and brushes, the front glass or even the inside of the turret glazing, was impossible. Having suggested a lowering and raising gear, I was forthwith dispatched to Cranwell to see if this was feasible and to take all necessary measurements, electric supply, etc.

"The Cadet wing, formerly housed in dingy black huts, had just moved into a splendid new building, clean of line, with a tower whose revolving beacon shown forth each night"

Peter Townsend

Cranwell College was still very much in the builder's hands and the nearest hotel was in Sleaford. To my surprise the hotel was crowded with newspaper reporters all waiting for the wind to change so that an R.A.F. plane, literally a huge petrol tank with wings and engines, to take off for (I'm almost sure) a non-stop flight to Australia. Remarkable was the memory. The aerodrome runway was extended over gently rolling Lincolnshire fields crossing two roads in transit. It made it – but what a sight it must have been taking off, alas I was back at Chances, or rather in bed, before a suitable wind came!

However, at Cranwell I was to find to my horror (no head for heights) that:

i) A howling, freezing gale was sweeping in down the North Sea.
ii) Not a square foot of the windows in the tower was glazed.
iii) The 3rd ladder looked a 40-foot rung and was at an alarming angle over the dome in the main hall.
iv) The water tanks had just been put in the room below the dome and some clot had not repositioned the ladder – meaning that at the top of the ladder one had to turn round whilst still on the ladder, then straddle the well hole and then on a 2" strip of floor on each side of the well hole shuffle across. To look down revealed, all of the well holes in line, meaning about 85 feet of nothing below!

Half way up the 40-rung ladder, with a motion in the middle like a trampoline, the gale ripped my coat open and wound it round my head! A muffled voice from the Clerk of Works, a few rungs below me "if you must fall, don't fall through the dome – its just been plastered!"

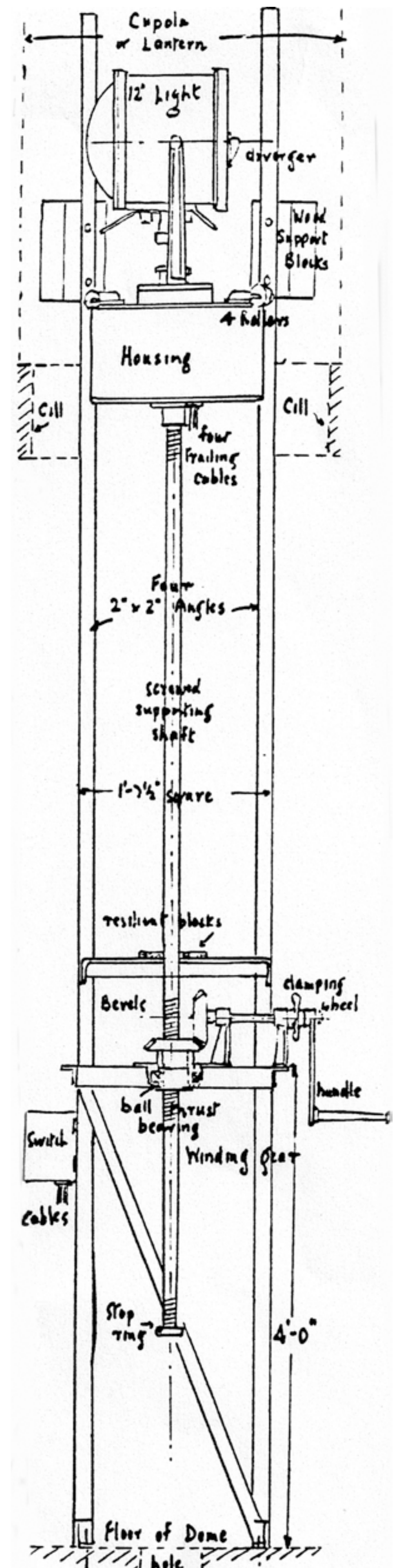
The tower dome was eventually reached and since it had no windows it was comparatively warm at a degree or so above freezing. Mind you, above ones head the gale whistled through the cupola or, as I shall call it, the lantern, and getting accurate dimensions of the inside of the lantern framework was agony! Moreover the carpenters engaged in a work of art, the lantern seemed to have an accuracy of plus or minus ½ inch, that had no appeal to an engineer.

As you will see from Fig. 13, I had to steady the four vertical guide angles by wooden blocks on to the lantern framework and I required a rigid anchorage. Having already decided to support the searchlight by a long threaded shaft I was relieved to see a 6" hole in the dome floor and also that the shaft when fully lowered would not foul the water tanks. The decent was safely made and so to bed, at home, with a stinking head-cold.

The final design had added to the 12" mirror 'canal' searchlight:
1) Electric lamp and holder.
2) On the frame of the front glass, a 0º - 20º glass diverging strip.
3) Two focusers.
4) A spirit level.

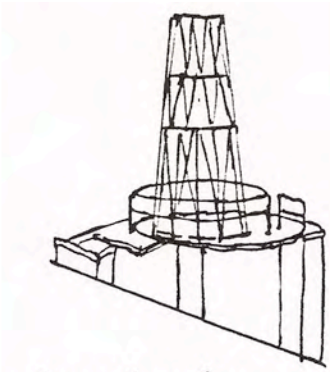
In the new design, the housing contained the motor reduction gear drive; slip-rings, and brush holders. The ball bearing 'pedestal' carried the revolving table, friction drive, and the top cover with four spring loaded rollers shaped to run snugly in the roots of the four vertical angles.

I hope Fig. 13 speaks for itself as far as the raising and lowering device is concerned. The supporting shaft is about 7 feet in length and 2 inches in diameter and has a 2 start ½ inch pitch square thread. This means that for every one revolution of the handle the shaft moves up or down 1 inch. The time to raise the beacon is around 2½ minutes. One snag with multi-start threads is the risk of winding itself down. It would never do at Cranwell to switch on and then the beams to slowly lower themselves into the dome! An unknown factor was the slight vibration from the gear drive. Many mechanisms can be eased (that is, inherent friction decreased) by building into the equipment a small vibrator, so for safety the locking wheel shown, was included. Maybe over the many years the beacon has worked, easement of the parts might well require the locking wheel. I think it's obvious, but the bottom level gear has a square threaded bush and can be regarded as a 'nut,' which cannot move up or down but only revolve. The supporting shaft – the 'screw' cannot revolve so on turning the 'nut' - the shaft must move up or down.



The Cranwell 12" mirror Beacon
Shown in partially raised position
Fig. 13

Chance Neon Aerodrome Beacon:



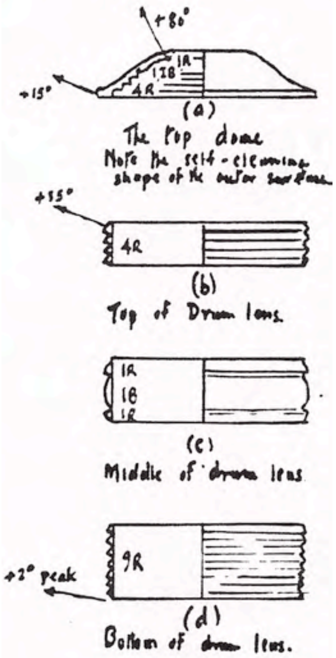
Chance Neon Beacon

Fig. 14

This not only locates the airport, but is erected actually in the airport. With its distinctive color and flashing character it is easily recognized. It is very “un-Chance” like with no lens, no mirror and since it was merely a steel structure, roughly 15 feet high on which was held longish lengths of neon tubing, it had no place in the departments manufacturing facilities. A flashing mechanism together with the usual control gear for the flight controller to switch it on and off was supplied. Talking to ex RAF airman I found it was quite popular and often referred to as the Chance Light.

The two beacons, described on pp. 6-8 can be erected on the aerodrome (In fact I have mentioned one in Belfast Airport) but to avoid the risk of dazzing the pilot during his run in, Chances preferred such powerful beacons to be a mile or two from the periphery of the airport. However if traffic was light the Flight Controller could switch the beacons off when a landing was being made. Fig. 14 shows a Neon Beacon at Southampton Airport.

Air Ministry: Aerial Lighthouses:



The fixed 250mm lens

* Fig 15(a)

The first was made in 1941 and used for marking a location by flashing a Morse letter every 8.4 seconds. The design followed the marine practice for an occulting light, except that the screens, now called shutters, revolved on the outside of the optic. By opening certain shutters a required letter can be programmed in Morse (from our alphabet the letters EJOQYZ are omitted).

Dealing with the Air Ministry MK III version the main parts are:

i) Optic: This is a 4th order (250mm focal length) fixed pressed glass optic, covering 360º in plan. Fig. 15 (a) shows the four pressings, which between them provide – in the vertical plane – a beam from 0º to 80º. The illuminant is a 3 KW electric lamp surrounded by either a clear heat resisting glass shade or one of selenium red glass. See Fig. 15 (b) also.

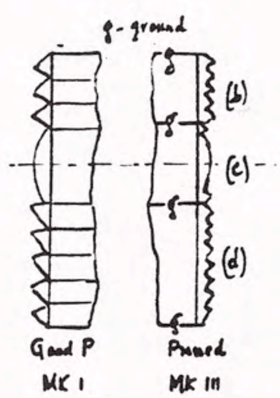
ii) The shutters number 14 that can be opened or shut; three supports with fixed shutters carry the conical nest of top shutters, and a large (about 120º in plan) screen in the form of a door completes the lower shutters. The top shutters have an approximate 120º screen but no door. The shutter carriage is supported by vertical and horizontal rollers and revolves at a speed of 7 1/8 rpm. This odd speed gives a 1/3rd second flash for a (Morse) “dot”, I second for a ‘dash’ and 2/3 of a second for the short, intervals. See Fig. 16.

iii) Fig. 17 shows the complete light in a sectional elevation and details the top ventilator and cooling air fan; the motor-reduction gear, friction clutch, drive; and the swiveling jacks for leveling the light.

iv) Fig. 18 shows the light and the bottom housing for spares mounted on a trailer together with the engine-generator set and switchgear. Further details, as required, now follow:

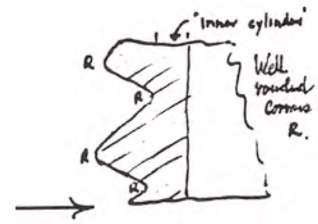
   a. Optic: Why the change from ground and polished prisms to a pressed glass optic? Just cheapness allowed by the enormous brilliance of the 3 KW. More efficient – a big no!

   b. Glass is pressed in a C.I. mold, internally cut with the shape of the prisms and belt, whilst the smooth internal bore is shaped by a slightly conical plunger. A ‘gob’ of ‘molten’ glass is dropped into the mold, down comes the plunger and the glass flows into the ‘female’ mold. Later the mold is opened and the lens annealed. The tops and bottom are then ground flat.



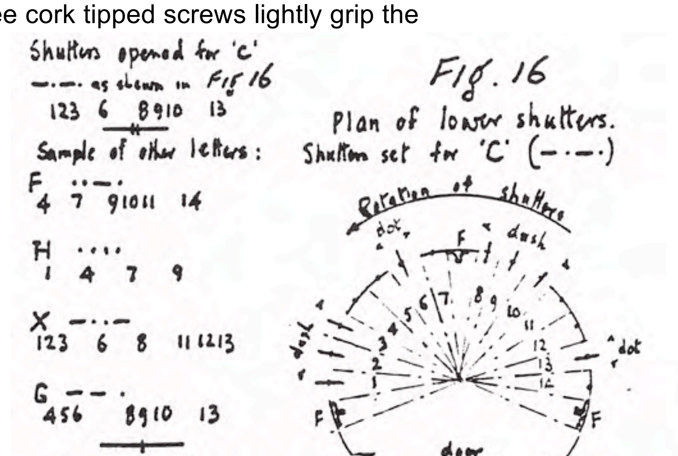
+ Fig 15(b)

Designing a pressed lens: When materials are formed at great heat, either a metal casting or a glass pressing, big changes in thickness must be avoided otherwise when the job cools seven internal stresses due to shrinkage will result and with castings, porosity in the thick portions also occurs. Annealing will reduce such stresses. A little story about 3 apprentices returning through the glass works who saw on a heap of cullet an apparently undamaged railway signal lens (pressed glass). We collected it for examination of the design, but while doing this in the Drawing Office, the Works Manager, Rawth appeared. So it was hastily hidden under a pile of blue prints. A few moments later there was a dreadful ‘explosion’ and several severely perforated prints rose upwards and the ceiling was peppered with glass fragments. Being scrap it had not been annealed and the locked-up stresses had completely shattered the lens! No one was amused but all agreed we had learned our lesson!

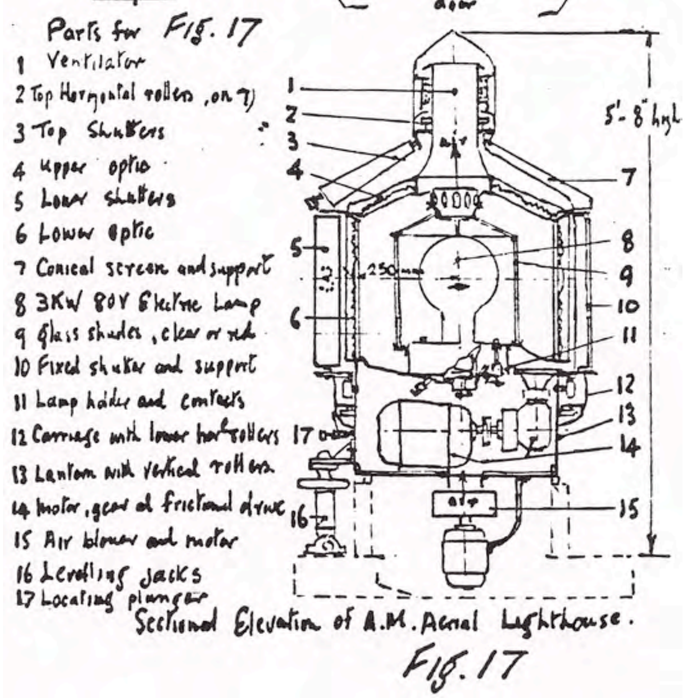


A glance at Fig. 15 (b) shows how severe changes in thickness are avoided by “building” a greater number of refractors on a very solid inner ‘cylinder.’ Additionally, sharp corners of the refractors are obviously out - see sketch.

The pre-focused 3 KW 80 volt electric lamp has the center of its filament set 8.5mm below the focal plane and this related to the focal distance of 250mm gives the main beam an elevation of + 2º. The lamp (11) holder is of the ball and socket type allowing the center of the filament to be brought on to the centerline of the optic by slightly tilting the lamp. When the focusers show the filament to be truly in position, three cork tipped screws lightly grip the (glass) neck of the lamp. To get at the lamp for renewal; the lantern door (10) is hand turned until a hinged stay can lock it in position relative to the optic door. This door is then opened and the clear or red glass shades (9) are then removed leaving the 3 KW lamp accessible. The shutter carriage (12): Fig. 16 shows the clockwise numbering, in plan view, of the top and bottom shutters. The three supports, both top and bottom are, in effect, three fixed or permanently closed, shutters (7 and 10). The one between No. 7 and No. 8 shutters is particularly important and all shutter arrangements must be centered on this, since it forms one half of the interval (2/3 second) between dot and dash. The length of the long dark period given by the other two “fixed shutters” and the large door is not important essentially one Morse letter is seen every 8.4 seconds. To follow common practice every dot is 1/3 second; every dash I second and the short intervals all 2/3 second.



To open a shutter: slack off the end clamping nut about 5/16 inch and push the shutter upwards when the pin in the shutter pivot is disengaged from one of the two holes in the carriage. Open the shutter 90º and pull it down when the pin will engage in a second hole, at 90º to the first. Tighten the clamping screw. Slipping when rotating in a high gale is thus impossible.



The carriage (12) is carried by vertical rollers (13) and steadied by the two sets of horizontal rollers (12) and (2). Immediately above the vertical rollers and secured to the carriage is the race wheel, a large diameter internal gear meshing with the R. W. pinion which is integral with the friction clutch (14).

A locating plunger (17) is fitted between carriage (12) and lantern (13) to lock the carriage when the trailer is being towed or the light is not in use. The Lantern (13): Fig. 17 shows the ventilator (1) for air handling the searing hot air from the lamp and the burner unit (15) which delivers 400 cubic feet of air/min.

You will see how this air divides between optic and the glass shade and between the glass shade and lamp. The driving motor (14) is ¼ hp. repulsion induction type and the output speed of the reduction gear is 21 rpm for the race wheel pinion. The three leveling jacks swivel at the base to allow for the inclination of the tractor deck, and also the housing, when parked. The large housing, whilst it supports the lighthouse, is a large spares cabinet for the spare electric lamp, glass shades, shutters etc. A step secured to the side of the housing is used when mounting the light or replacing the lamp.

The generating set and trailer : a parts list follows :

1 Aerial L'house - see Fig 17.	4 Mains supply socket	7 Radiator cover
2 Air duct on housing	5 Engine installation	8 Hand starter
3 Transformer	6 Switchboard (Gen. behind)	9 Fuel tank under trailer

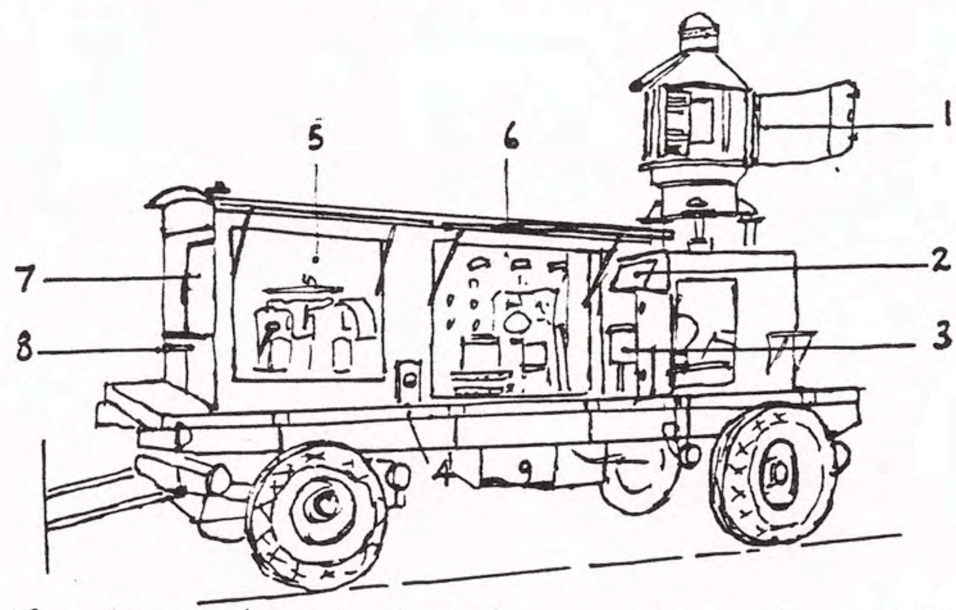


Fig. 18 Aerial Lighthouse. MK. III. (doors opened)

The engine installation (1) was comprised of a Coventry Climax 4-cylinder water-cooled engine driving at a governed speed of 1,500 rpm a GE 230 Volt 50 cycle single-phase alternator delivering 5 KVA at a 0.8 power factor. A radiator and fan formed the cooling system.

A Lucas 12 Volt generator provided general lighting; inspection lamp; warning lights and 'road lights' for the trailer via a 10-cell nickel-cadmium battery. The current for the 3 KW cruciform-filament lamp was supplied by a GE 3 KW air-cooled core transformer (3) reducing the voltage from 230 to 80. A dimming choke limits the lamp current to 31 amps for starting up and controls running current to 37.6 amps.

The Chance switchboard (6) includes a manual change-over switch from the mains supply (4), should this be available, to the generator supply; an alternator field rheostat; a transformer tapping switch; a main lamp dimming switch and an engine speed indicator. Both engine and alternator have ample air filters.

It was an excellent generating set, particularly the engine. The trailer, a Brockhouse torsion bar type with all four wheels independently sprung. It was quite amazing to see one wheel down a deep hole another up a bank and still the deck was level!

There was an interesting under current among the shop fitters that such ‘deluxe’ trailers should not be used for Aerial Lighthouses, and indeed it was known that their service for field kitchens was excellent in safeguarding the crew from accident. My own feeling was that the optic, shade and lamp and especially the shutter carriage required a smooth ride!

Luminous Ranges

I cannot resist the temptation to take out the differing ranges for the +2º portion of the beam, for a dot (1/3 second) and a dash (1 second) for both white and selenium red beams, despite the fact that I do not know accurately the proportion of dioptric prisms contributing to the +2º beam. (see Fig. 15a on P. 11)

However a similar pressed, fixed lens with a 1½ KW lamp is listed by Chances as having a white beam range of 26 miles with T = 0.85. Its Ia would be 30,000 candlepower and using a 1/3 sec. flash (the dot) and correcting for the differing brightness of the lamps (3KW = 970; 1½ KW = 750) we get Io at about 60,000 candlepower for the Aerial Lighthouse.

Losses due to the green shades: for the clear glass transmission = 0.9 (10% loss) and for selenium red shades, transmission = 0.2 (an 80% loss) we get corrected Io’s of 54,000 candlepower for the clear glass and 12,000 candlepower for the red shades.

Blondel - Ray factors are given in the following table:

T sec.	B.R factor	I_a^o White	I_a^o Red	Range with T = 0.75 in miles White	Range with T = 0.75 in miles Red
0.33 (dot)	0.77	41 700	9250	18.0	14.4
1.00 (dash)	0.91	49300	10900	18.4	14.8

To conclude – with all the overall weaknesses in such calculations we can see from the closeness over the ranges for the dots and dashes the pilot would quickly get the true Morse letter and even with the terrific losses incurred by using red shades the range of 15 miles or so would be satisfactorily with the then plane speeds of around 200 mph. Anyhow, it was a good looking and reliable job and I’ve no doubt it was a lifesaver for many an RAF plane limping home on one wing!

Wind driven Sun Beacon for India

This beacon was unusual in its begetting, sad in its ending, and betwixt and between the less said the better!

In mid 1935 the Indian Air Authority evidently asked Chances to produce an airway beacon, for day flying only, to be sited at the head of the Thar desert, to the following specification:

Illumination by using the ample supply of sunshine, to give a flash every 5 seconds. The beacon to be wind driven, again plenty of wind, the N.E. trades plus ‘cyclonic’ storm centers to east and west. Rotation to start at 5 mph wind and to finish (ie: ‘take off’) at 75 mph (good grief).

The reflecting surface to be at least 15 feet from ground level to avoid abrasion in a sand storm.

The Design:

The reflecting surface gave the optical experts little trouble and in turn they specified a semi-cylindrical surface of highly polished stainless steel sheet, mounted horizontally with its rotation axis vertical.

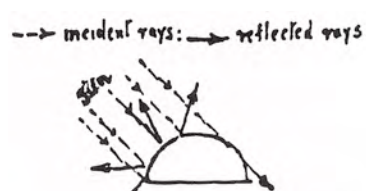


Fig 19

End elevation of semi-Cylinder

As shown in Fig. 19 over the sun can be taken as normal to the axis and the reflected rays will thus give a fan of light of angle totaling the 180º arc above the horizon and twice the angle of the sun below the horizon, thence the whole hemisphere is swept by the fan of light.

Since the speed of revolution of the semi-cylinder is 6 rpm or 1 revolution in 10 seconds the pilot we'll see, from each side of the semi-cylinder, a flash every 5 seconds. The divergence of the rays of light is very, very small so given a flash of duration 0.015 seconds. I believe this value is just below the value when the observer not only sees the flash, but can indicate its source. I can surmise seeing the flash only, in some way, helps the pilot in flying over a featureless desert.

Alas the simplicity of the shape of the reflecting surface, despite my unaided efforts, spelt out its own doom, since all it wants to do is to 'hunt' (and engineering term) or oscillate in a steady wind. Fig. 20 (a) refers. My notebooks show no preliminary design work on the wind drive, so I can only conclude that Chances, once the optical experts had done their stuff, accepted the order possibly on a "cost + %" basis. Further knowledge of this hunting and the forces involved over a complete revolution from winds of 5 to 75 mph could only be obtained from a model in a wind tunnel. Wind tunnels in those days were few and far between – and expensive to hire time. So being Chances not a chance.

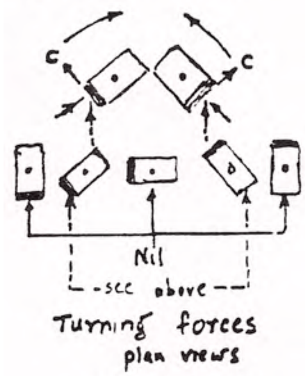


Fig 20(a)

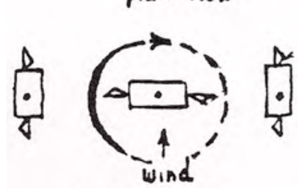
So what to do? Remember we are in the period 1935-6. Smallish windmills were indeed used, mainly on farms, but far more seemed unserviceable and rusting away than those working. As for 5 mph, a gentle breeze turning-em round, never!

It is amusing it read in 1979 a scientist saying that the proposed giant windmills of the future should stand in enclosed land, so that a blade when it breaks off doesn't kill the passerby! Better still to read in the *Industrial Mechanical Engineering Journal* that such blades ought to be painted red to keep birds from flying into them and so causing incipient failure!!

But, firstly to stop the hunting of the reflecting surface, if possible. Using packing room scrap, wood slats and zinc lining sheet we rigged up a full six semi-cylinder 4 ft. long, 1 ft. radius, mounted it on a small spindle and secured to each (flat) end a conical cup (to simulate a semi-spherical cup) 9 inches diameter, 4½ inches deep. But, what a sick joke trying to observe with no "permanent" observer in two weeks of near calm. It was a blessing when a storm then blew up and we found the splintered and tattered remains on the football ground! In calm weather the "model" did not oscillate but revolved at anything but a constant velocity. So "cups it was". Hope eternal! Fig 20 (b) refers.

The Anemometer drive

Now the problem of rotating the semi-cylinder at 6 rpm. Anemometer cups? Why not use four of them? (Nowadays 3 only are used for the wind-speed instrument). But, the snag is that a 5 mph wind exerts but 0.125 lb (2 ounces) per square foot of projected area whereas at hurricane speed 75 mph, 30 lb is exerted. Good grief, a ratio of 240!!!



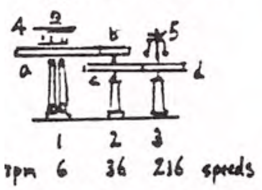
The (sic) experiment
--- we hoped!
Fig. 20 (b)

This could but mean:

The frictional torque of all the rotating parts must be very, very small at around 5 mph. That is the parts must be very light, but very strong at 75 mph and all supporting shafts and bearings very small also.

Once the anemometer cups exerted sufficient force (hopefully at 5 mph wind) then no further energy from them was required – say from 6 mph to 75 mph wind. A tall order! This would require a slipping drive between the cups and the semi-cylinder. Slipping indeed at around 200 rpm in a hurricane!!! What surplus energy did get through to the semi-cylinder would require a small friction governor driving through gears from the main spindle supporting the semi-cylinder. More frictional loss through the two spindles and gears! What did we know about wind forces on anemometer cups? Only that Routh's book (he was an eminent Cambridge mathematician), published in 1880, describes an experiment he conducted by mounting a small 4 cup anemometer on the edge of a showman's roundabout (he really suffered from the lack of a wind tunnel) and so establishing the rather remarkable ratio, wind speed divided by tangential speed of the center of the anemometer cups = 3/1. Since he was but driving a wee mechanism, giving the speed of the wind in mph, he was not concerned with the wind forces on the cups, a force that varies continually through one revolution! All in all, not too useful. Again a wind tunnel, not likely! So as shown in Fig. 21 it has four 11-inch cups at a radius of 24 inches. A few, very few, snippets from the design follow:

Gear train for driving Governor:
Parts list:
1 Centre shaft supporting the semi-cylinder : 6 rpm
2 Second shaft : 36 rpm
3 shaft with governor: 216 rpm
4 Slipping frictional drive
5 Governor - frictional
ab and cd - gears each with a ratio 6 : 1



Frictional Losses:

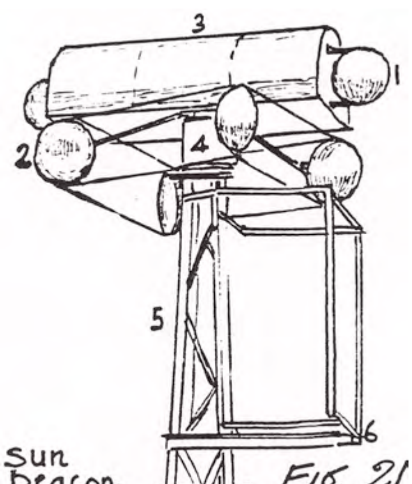
Total weight on bearings (Col. 2)	Bearing "arm" (col 3)	Frictional torque referred to shaft 1. (a) (b) (Col 4)	
43.79 lb *	.33	.0462 × 1	= .0462
0.67 lb	.38"	.000856 × 6	= .0052
2.22 lb	.38"	.00281 × 36	= .0101

* includes 14.18 lb for the stainless steel reflector. Total .06 lb in.

Notes: Thrust friction of ball bearing = .3%: Column 4(a) is Column 2 x Column 3 x .003. Column 4(b) one the gear ratios referred to shaft 1. Journal bearing friction is .2% – ignored for a 5 mph wind.

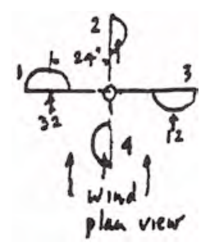
Sun Beacon
Parts list for Fig below:
1 Compensating cups, 9"
2 Driving cups, 11"
3 Reflector, 4ft x 1ft rad.
4 Casing for governor & shafts
5 15 ft high structure
6 Access platform

Force (P) in lb / sq ft of projected area for various Wind speeds (V) in ft / sec: Moles-Worth gives $P = .0023\ V^2$. If speed is 75 mph then V = 114 ft / sec and P = 30 lb. and if speed is 5 mph then V = 7.2 ft / sec and P = 125 lb or 2 ounces. This is a ratio of 240 to 1.



Sun Beacon Fig. 21

Force on cups for position shown in sketch below:
Cup 1: projected area = 66 sq ft: coefficient of roundness = 1.6: Wind speed 75 mph with pressure of 30 lb / sq ft.
Force on cup = 66 x 1.6 x 30 = 32 lb. Cup 3: coefficient = .625 and Force = 12 lb. Cups 2 and 4 cancel out each other when turning. Hence torque at 75 mph = (32 -12) 24 = 480 lb in. At 5 mph = 480 / ratio 240 = 2 lb in. this is equivalent to a spring balance hooked at the centre of a cup and reading 1 1/3 oz! Compare the 2 lb inch with the friction .06.



Materials: Highly stressed parts were made from: Cup holders and brackets – heat treated aluminum alloy castings. Cup, tubes etc. drawn aluminum. Center shaft, then the strongest steel – 'Vibrae'.

I was absent when assembly commenced but was appalled on return to find it in a packing case. Tested obviously not! Governor and slipping clutch adjusted for best performance – no! Reason for the rush I did not know – then. On reflection now I think I do. I got a photograph! Long after my 20 years I heard it was a failure. I guess it languished in its packing case for a long time – the long built up to WWII! But I guess no one worried – navigation had improved and the beacon was obsolescent.

5 Illuminated Wind Direction Indicators

Whilst the flare held its own for many years, the advent of regular night services demanded a clearly seen wind direction indicator so that the pilot could determine his correct line of approach. Four types were developed:

1) The free riding type comprising a 20 foot by 20 foot tee with a streamlined vane. It had two disadvantages; with every slight change in wind direction it jigged about and at zero wind it came to rest in any position, whereas most aerodromes had a “preferred position”.

2) Master and slave type; a very small ‘master’ wind vane was mounted on the top of the large ‘slave’ tee and this controlled all movements of the ‘slave’ tee. For example an Authority might specify – “No movement of the slave tee unless the direction of the wind had changed by 10º or more for not less than 30 seconds”. Additionally the main tee had sloping or drooping wings, giving it, in the words of the then national air magazine, “a dying duck appearance”.

3) Tower controlled by the fight controller up to about 35 mph wind, when in case the tee took off before the plane, he pressed two switches and the tee became ‘free riding’. A clutch on the main tee supporting shaft and a device to disengage it when free riding, was necessary.

4) Preferred direction type: (as the free riding type) but, a simple cam, with a special thrust bearing for the supporting shaft, saw that at near zero wind speed the tee took up the preferred direction for landing.

Instruments for the flight controller: His desk often included wind speed and wind direction displays and almost a ‘must’ was a display giving the position, at any instant, of the wind tee. The later required a torque motor or an ‘8 point’ switch in the main tee.

Illumination of the tee: This size of the tee was determined by experiment and 20 foot by 20 foot it remained. The top surface was painted white and was lighted at night either by electric lamps protected by bell glasses or by fluorescent tubes. The electric supply, at mains voltage, came through carbon brushes (stationary) and gun-metal rings attached to the revolving shaft supporting the tee. Further details of the 4 types follow:

1) Free Riding Tee - Fig. 22 refers. (This was designed for the Air Ministry in 1934)

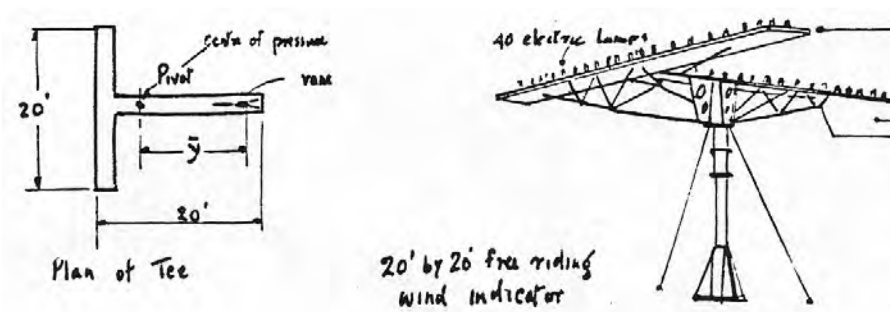


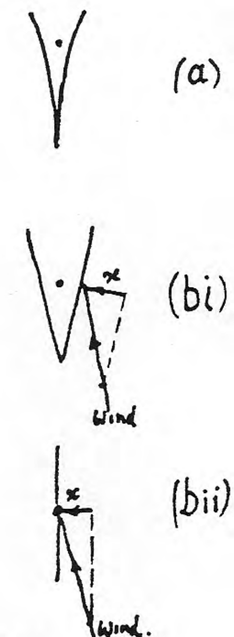
Fig 22

The construction was largely sheet on a tubular frame. The upper surface of the tee was painted white, for day purposes but a useful reflector at night, and carried 40 light fittings approximately 12 inches apart. The electric lamps were protected by bell glasses.

Materials included:
1/16 lead coated steel sheet – 76 sq. ft. for the tee and 16½ sq. ft. for the vane;
1/16 thick by 3” diameter steel tubing – 137 ft, weight 270 lb.; Total weight 2308 lbs.
3 inch x 1 inch teak battens 67 ft. – weight 100 lbs.

Main supporting shaft 6½ inch outside diameter by 6 inch inside diameter, weight 60 lb. 3 feet 6 inches long. These four items accounted for 710 lb. out of a total revolving weight of 950 lb. If the tee is balanced, and it should be even if the balance weight is of the order of 120 lb., then at very low wind speeds the only load and so the only fractioned loss (0.002) is in the ball bearing (thrust bearing) on the supporting shaft. A wind speed of about 4 mph. set the tee moving. Granted the "jigging" is decreased by an all aluminum tee but the extra expense is not justified.

Wind Vane: Shown is sketch (a) our design is very stable, compared with a single plate, straight vane. Sketch (bi) shows a simplified vane under a wind shift of 10º. Resolving the total wind force shown, it becomes obvious, that the normal component of this force is greater than the normal component of the same force on the straight vane shown at (bii). Moreover in (bi) the centre of pressure moves out and so usefully extends the arm Y̌ shown in sketch on page 17 and this, in turn, increases the driving force on the tee.



Sketch plans of wind vanes

x : the normal component (the turning force on the tee) of the total wind force on the vane
: the centre of pressure.

I give now an extract of a report dated August 1934 from N P L on this tee: "at 20mph wind speed the period of a complete swing is 15º per second, the amplitude of the swing being reduced by half for every complete swing, at 10 mph need 30 seconds instead of 15 seconds.

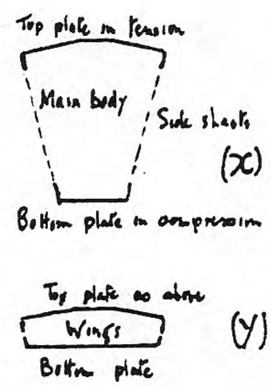
The forces on the vane are only proportional to the wind angles to some 20º using this for a 90º amplitude, then after 4 swings the amplitude would be 5½º. Times are 60 seconds for 20 mph and 120 seconds for 10 mph.

The minimum wind speed depends on the allowable error in wind direction, say 3º. If the coefficient of the ball bearings is 0.005, the minimum wind speed for rotating the tee will be 5 mph or if 0.003 it will be 3 mph.

2) The Automated Tee or "master and slave" - Fig. 23 refers

I don't think the word 'automated' existed in the 1930's so let it be that the 'master' was a wee wind vane as used in meteorological instruments mounted on the very large 'slave' 20 foot x 20 foot main tee. Essentially "wiggling" was cut out and a good minimum wind speed obtained. Moreover the addition of a push button or two could override the automat and so give the flight controller the means to set the tee in the 'preferred position'. I don't think it was ever done.

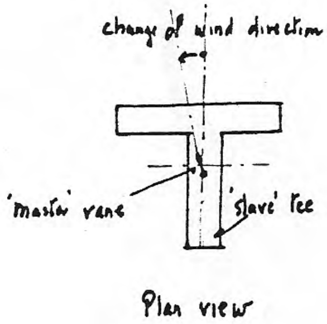
The consultant for the customer was Group Captain Helmore and he wanted drooping wings for the 20 foot by 20 foot tee. This shook us and I was detailed to see Helmore in his London Office. I returned very impressed with Helmore as an engineer and a man.



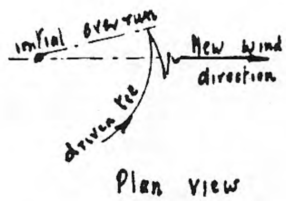
Automated tee
Body and wings sections
(see Fig. 23, p19)

He said that a pilot making his approach could misread a flat tee, but drooping wings could obviate this. Having, at this time, never flown even as a passenger, I couldn't argue but..! Helmore thought lunch might resolve matters particularly he got an assistant to make two wee models one flat, the other drooped, so that after lunch we could clamber up his roll top desk and so, in effect, view them from around 8,000 feet!

Later having sent for the assistant with the models, we 'climbed' and stood teetering on the narrow top of the desk. The assistant knocked and entered and nearly fled back again! Whilst he may have been used to seeing his boss with head at ceiling height, he was not expecting to see the visitor to be an old mate of his of the Smethwick Technical College School. We had not met for around 10 years.

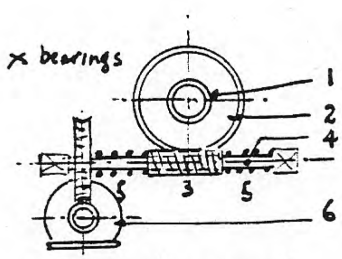


In the end I agreed to a ‘dying duck’ attitude for the tee, an expression to be used later by the then National Air Magazine! However, to leave shapes for a moment and to look at the means by which the master vane controlled the main tee’s position. Fig. 23 and 24 refer. The box 2) on which the master vane 1) is mounted contains a trigger mechanism driven by the vane 1) which tilted a mercury switch, if, and only if, the wind changed direction by 10º or more. The mercury however flowed through a constricting tube and took 30 seconds before the circuit was closed starting the driving motor which drove the slave tee round until it lay directly under, and in true wind direction, the vane 1). The trigger mechanism then re-set the mercury switch, the flow of mercury being now unimpeded. The motor stopped instantly since it drove the tee through a non-reversible reduction gear, and very slowly. However, let us suppose that the master vane veered 10º but only held this position for 15 seconds. In swinging back the mercury switch would be reset and no motion of the slave tee 3) would take place. But, back to the instant of stopping the drive motor and to consider Newton and his law $T = I \times \lambda$ when T is the retarding torque required to stop the main tee if the deceleration is λ radians / sec^2 and I is the moment of inertia of the tee about its rotating axis.



If it could be stopped instantaneously then λ would be infinitely large, and T, and we could sweep up the bits left! So (λ) must be strictly and accurately limited by using a small overrun and then let it oscillate very briefly (see sketch herewith) until it lines up on the true wind direction. Firstly, Sid Peters a colleague in the drawing office, and whose work I always trusted, had the laborious job of calculating the center of gravity of the main tee and its moment of inertia about its rotation axis. It took a week!

Once we knew (I) and had decided on the overrun and (λ), we could use T to stress out the supporting shaft etc. and fully detach the gear-box, which contained a simple but very clever device.



A sketch plan view of special reduction gear

Fig 24

Fig. 24, I hope speaks for itself. The worm-gear 3) which engaged the worm-wheel 2) carried on the supporting tube 1) for the main tee, could slide along the splined shaft 4) with its six long keys and 3) which had six keyways with a sliding fit. The worm was centered by 2 stout springs 5) visualize then the motor 6) stopping, practically instantly, and the shafts in the gear-box locked by the two sets of worm and worm-wheel gears, 1) and 2) overrun but 2) cannot turn 3). It can, however, push the worm against the springs so absorbing the rotational energy of the tee. But, after a few oscillations (see sketch above) the two springs center the worm, and through the worm gear of the supporting tube, the main tee is lined up with the true wind direction.

I had early decided to have box sections (see the sketch on page 18 for the box sections) for ‘wings’ and body with but two tubular stays. Costs would be lower and our expertise with sheet forming used fully. With the motor drive, revolving weight was not so important. Despite the ‘drooping wings the appearance was pleasing. Performance of the tee was excellent and it was interesting to see how smoothly and quickly the tee came to rest on the line of true wind direction.

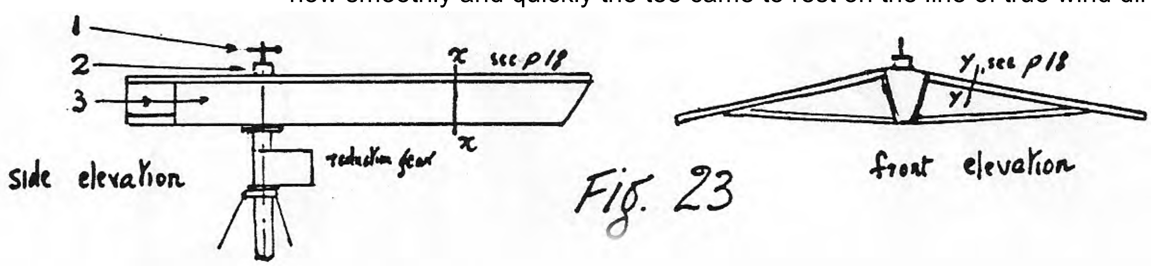
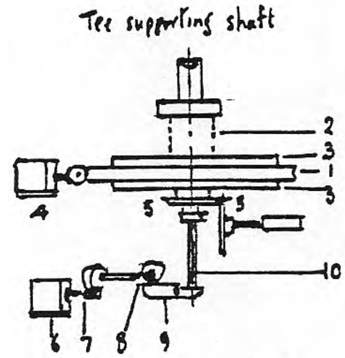


Fig. 23

I was very sorry, during World War II, to hear that Group Captain Helmore had been killed when a RAF plane crashed on landing at Gibraltar, then not the easiest of aerodromes on which to land. It appears he was in the second pilot's seat when both engines failed on the approach run into Gibraltar. He ordered all the crew into the tail of the plane and crash landed. He was killed but his action had saved all the others. What did Scott of the Antarctic say of Oates?

3) The Tower Controlled Tee



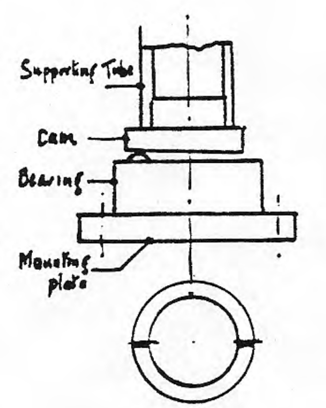
Tower controlled tee (GEC) Drive and clutching device

Fig. 25

The G.E.C. device declutches the tee from the motor drive (controlled by the flight controller) when the wind is above 35 mph. For the tee to be caught by a violent squall, off the direction to which he has set it and with the clutch 'in', is to invite a structural failure of the tee.

Fig. 25 is a sketch of the device. Worm wheel 1) is clamped between the two clutch plates 3) by spring 2). Through a reduction gear worm wheel 1) is driven by the fractional hp. positioning motor 4) as dictated by the flight controller. Gears 5) of a 1:1 ratio drive either a torque motor or an eight-point switch, which display on the controller's desk the position of the tee. The clutch motor 6) drives the cam spindle 7) on which is mounted cam 8). On starting the motor the cam depresses lever 9) which in turn pushes up rod 10) which relieves the clutch plates of the pressure on them. The supporting shaft of the tee is thus freed to revolve under the influence of the prevailing wind, whilst motor 4) and worm wheel 1) remain stationary. Importantly no electricity is required (except for lighting) whilst the tee is 'free riding'.

4) The Preferred Direction Tee - Fig. 26 refers.



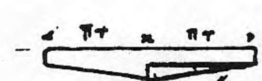
Face of Cam

Fig. 26

This device of mine ensured that at vary low wind speeds the tee automatically slipped back into the preferred direction for landing. The special thrust bearing supporting the tee is loaded through an offset ball and is mounted on a plate, which can be orientated, on erection at the aerodrome, to the preferred wind direction. The bottom of tee supporting shaft is 'plugged' by a minutely inclined cam, which rests on the offset ball.

If we start with the tee in the preferred direction then any wind 'pressure' on the vane above 3 mph will lift the tee and the cam upwards until the tee takes up the true wind direction. If the wind again falls to 3 mph the force on the vane is insufficient to hold the tee and cam up against gravity and it sinks to its lowest position, which is of course the preferred position. Cheap and very effective!

Since we are inducing a very minute error into the wind direction of the tee we want to keep the incline of the cam small. Let us equate the loss of potential energy of the rotating parts, over a travel of 180º to the work done against friction in the bearing over an arc of 180º. The calculations work out to just 35 minutes of angle – very small indeed!



Development of cam (the inclines are exaggerated)

It was made a little larger to allow for air drag; wear on the cam and frankly to help the machine shop, also the slipping friction and journal sliding. [An omission which, you will have realized, the two journal bearings on the supporting shaft of the tee had to be roller bearings to allow for the small amount of axial movement of the shaft].

6 Other Lights: ‘Aldis’ Lamp and Generating Sets

Cloud Ceiling Light: Even now the height of the cloud ceiling is important when landing in poor weather. In essence the ceiling light is a small searchlight which illuminates the cloud base and is used with a Clinometer which is mounted, usually, 500 feet from the light and on the same level. Fig. 27(a) shows the 12” glass mirror with a 400 W 115 V electric lamp at its focus and a louver with a small mirror to cut out stray coming direct from the filament. The body k of steel sheet 15½ inch diameter x 12¾ inches high with the top glass door sloped at 2½ inches to obviate (in rainy weather) a pool of wind disturbed water on the glass door. The Clinometer is of aluminum and has a scale graduated in height of ceiling, a sighting arm and a ‘V’ sight. Fig. (b) shows a table of x values with their corresponding k° angles used for engraving the scale.

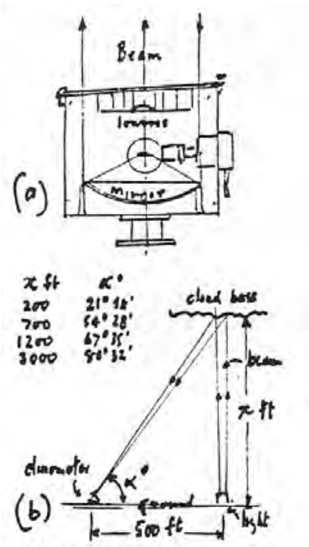


Fig. 27. Ceiling Light

Obstruction Lights:. Fig. 28(a) with globe and (b) without globe. The light shows all obstacles dangerous to an aircraft approaching to land. The glass globe is of Aviation Red in color and light is shown from 30º below the ‘horizontal’ to 90º above – in all directions. The two 40 W or 60 W lamps are in circuit with the small solenoid relay. This ensures that only one lamp is lit on first switching on, but should this fail the solenoid is de-energized and the relay contacts the circuit of the second lamp which lights up immediately. Maximum safety is thus assured and current saved.

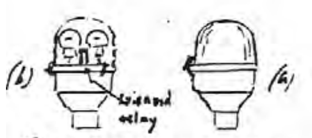


Fig. 28. Obstruction Light

Boundary Lights: These define the landing area and by there size and appearance give the pilot ‘perspective’ when touching down. Fig. 29 shows its excellent appearance at night. The 5 inch diameter glass globe is Aviation Yellow and holds a 6.6 volt, 6.6 amp electric lamp supported by a metal reflector which illuminates the cone and adjacent grass.

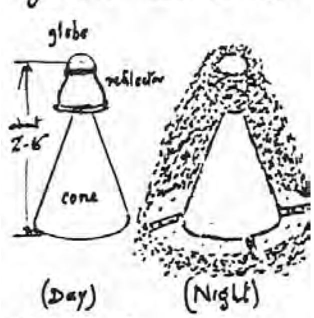


Fig. 29 Boundary Light

The design has several points of interest since the early planes were fragile, with no brakes and runways did not exist. To avoid much damage to the plane when it ran into a boundary light it was essential that 1) the light had little weight 2) on contact the light should ‘take off’ and this required an instantly breakable joint or sleeve and 3) cables should not be exposed and in any case a transformer (below ground) must reduce the lamp voltage, in this case to 6.6 volts. With a single cone ring cable a single pin contact instantly broke the lamp circuit when the light ‘took off’. No risk of fire! The total weight above ground was 9¼ lb.

Runway Marker Lights – if any runways: The lamp in its metal box is covered by a heavy stippled glass dome capable of standing a direct ‘bump down’ from the heaviest of aircraft. Colored glass filters can be fitted inside the shallow dome giving white for a prepared runway; red for a fog runway and green for other tracks. Spacing ranged from 50 to 100 yards. As with the boundary lights a single cone cable is used, arranged so that a failure of one will not effect the others in series.

Portable Flares Fig. 30 refers: For use on an aerodrome without floodlights. 12 feet of neon tubing is wound into a cylinder 8 inches in diameter by 8 inches high. The accumulator in the base is sufficient for 12 hours of use, total weight 35 lb.

The Aldis Signaling Lamp: This lamp is well known to all three services and has a high reputation for Morse signaling over long distances, for example, from the airport tower to the on coming pilot, a feature is that the electric lamp is not switched on and off, except at the commencement and end of the message, but using the Morse trigger the mirror rocked so that the beam moves out of the pilot’s line of view. Fig. 31(a) refers). Fig. 31 (b) shows a section of this unique mirror (made by Chances) with its two spherical surfaces of different radii.

The back surface is, of course, silvered. If you will in your imagination flatten out the section given you will see how a slight correction is applied to the ‘spherical’ errors in reflecting the light from the bulb. Result a very true beam required for speedy signaling.

Fig.30. Portable flares

A Mooring Mast Light for the great flying boats: These great and luxurious boats flying to Australia and the Far East were put to grave risk, when compelled to move (at night) is some busy river or estuary. The local boatman, with their junks, or whatever, had little knowledge of flying boats and their many problems, so lighting units comprising a wee mast, hinged to lie flush with the top of the wing when in flight, topped with a colored light, were required. Awesome figures were quoted for the cost of transporting one ounce of extra weight to Australia, I found, looking at the boat itself and its passengers, not impressive, but some new materials, called plastics, just had to be used! I do recall the plastic tubular mast was a vivid-yellow plastic reinforced with layers of ‘cloth’. I wonder if they ever forgot to pull the levers which lowered the light, for taking off. Not that it would have mattered much – speed was very slow. Anyhow when landing the Coy flag was poked up through the fuselages roof!!

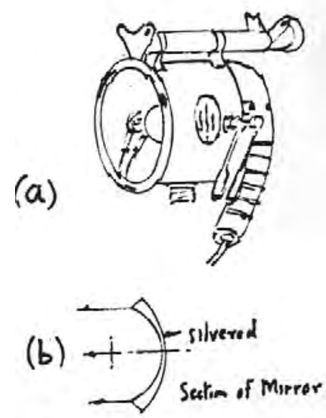


Fig. 31. The "Aldis" Signalling Lamp.

Generating Sets for Automatic Beacons; Control Panels: Beacons could be positioned in very remote areas but Chance Brothers had available an unattended type which automatically, using a light valve, provided an electric supply in the evening and cut it off at dawn. Such sets could run for eight weeks with no attendance what so ever. In areas not so quiet and with unskilled labor available, a duplicate set of generators with a control cubicle could be supplied.

Control Desk for use by the duty officer in the Control Tower: Small flush switches controlled all lights used and indicated on the desk when ‘on’. A wind indicating dial showed direction and speed and with a small plan of the aerodrome enabled the duty officer to determine the correct floodlights to be used. Obviously the control desk worked in conjunction with the main switchgear.

To tales:

1. The glasses used for the mooring mast were about 2 inch diameter and molded in the Glass-Works. They also made others streamlined for flash mounting on the wings of other planes. One of these we would as a cover glass for the key to the ammunition cupboard in the Home Guard room. As Chief Officer I was duty officer one night when sector came through saying a German aircrew was suspected of parachuting into waste land near you. Send out a ground patrol. Great excitement but alas we could not break the cover glass even by bashing it with the butts of the (heavy) Ross Rifle. Panic, until we found a screwdriver to release the retaining plate and all! It was, of course, a false alarm.

2. I recall, some miles north of Lima, my taxi turning off a road on to the brown desert, a bit awesome in pitch darkness. I was ‘booked’ for a festival of Inca dancing adjacent to a remote museum of old costumes, musical instruments, etc. The driver was not certain, but we hit a narrow passage and half of the track was lit on each side by air-force flares. The show was splendid – completely unique! My driver was 1/3 each of Irish, Spanish and Indian at six feet plus tall.

7 Searchlights

Although possibly off-beam (off or on!) it seems a pity not to conclude with the most powerful light Chance Brothers made – and we made well over a 1000 of 'em!

It was, I think, in late 1937 that Jack Dodds and I went down to Woolwich to see a 90 cm (mirror size), 200 million candlepower searchlight, to study it – with some other firms – and to be told of the need for a quantity production for the protection of our factories against the heavy air attacks in the expected war.

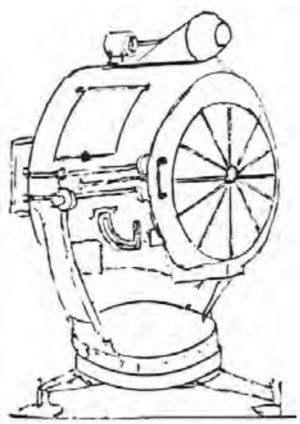


Fig. 32.
90 cm Searchlight

We were informed that the mirror glass would be provided by C. A. Parsons and that silicon aluminum castings were 'out'. We were required to redesign (but interchangeable) the two trunnion supports and the two base castings using mild steel with welded fabrications. Later we got involved in two most difficult tasks: 1) making sound location units to pick up and track the sound from enemy aircraft and 2) the control gear to coordinate the movement of the sound locator with a very large searchlight – 150 cm metal mirror from, I think, Savage-Parsons; the searchlight itself, I think, from Clarke Chapmans. The candlepower of this was 500 million! It seems that enemy aircraft were flying much higher leaving the hand operated 90 cm searchlight at a great disadvantage.

90 cm Searchlight: Fig. 32 refers. The important parts are:

1. The mirror 90 cm diameter 375 mm focus; glass 11 mm thick. With deposited silver: electrolytically deposited coat of copper: a varnish and paint backing and finally Parson's patent lead and wire backing.
2. An arc lamp – and as opposed to marine lights – we can effectively use the intense light streaming from the crater of the positive carbon.
3. A brush and ring system in the base to feed 100 volts DC current to the arc lamp.
4. A motor-driven fan-exhaust system to get the searing heat of the arc out of the searchlight body. Note in Fig. 32 we don't bake the motor!
5. Trunnion mountings for the body to move 0º to 90º above the horizontal.
6. Mountings in the base for turning the complete unit round and round.
7. A 'sectored' glass front with louvers to cut out what little stray light exists. The whole is quickly removable.
8. A device to very quickly de-focus the arc lamp and so widely spread the beam should an enemy aircraft dive down the beam with the aim of destroying the crew and the light.
9. The crew member engaged in tracking a target must be some feet from the searchlight. This is done by 'hooking' on the searchlight a long and flimsy looking tubular frame which he pushes for movement in azimuth. A driving shaft with a largish hand wheel, for elevation movement, is incorporated. (I don't think Chance Brothers made this).
10. Balancing tubes on each side of the body enable the body to be moved horizontally relative to the trunnions. When in operation the body must be accurately in balance for smooth and precise hand operation.

D. T. 9-19-1978

"The last of the British Airway's 1935 vintage searchlights are being retired. The final eight 200 million candlepower carbon arc lights are being replaced by new Xenon units with four times the candlepower.

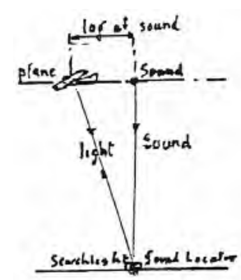
The lights were used for battlefield illumination..."

150 cm Searchlight: I refer only to those supplied to us for 1) fitment of the arc lamp and the complete control gear for working with the Sound Locator. 2) testing and tuning them as a pair, a 14 core cable connected them!

The mirror was 150 cm diameter: parabolic in section and 650 mm focal distance; of metal depositions highly polished. So the ratio of mirror diameters was 90 to 150 or 1 to 1 2/3: The ratio of mirror areas was 2.78 implying that the candlepower, all other things being equal, should be around 556 million, but as measured by the War Department, 500 million candlepower. The volume of the searchlight was larger than the 90 cm version, that is a ratio of 1 to 4.6, and it looked it. This meant it had to be trailer mounted, something like that shown on Fig 4 of page 4. Someone in London issued an order that these must be delivered by rail to save petrol used in the towing. The railway thought it was too high even on an extra low loader, but could we do the mile to the Rolfe Street Station. It took 3 days to get the cupful of petrol required but certainly interested people in the High Street. Alas, it was too high to clear the tunnel. Anyhow it wasn't a clever idea.

For the 5 KW mobile floodlight the generators sometimes ran noisily. Eventually we traced the trouble. All batches delivered by road were quiet, those by rail noisy! The railway lines agreed the un-welded track rails and the continued bump-bump over the rail joints slightly hammered the bottom balls of the shaft bearings into the outer race. Both the searchlight and sound locator had many bearings!

Azimuth and elevation movements were motorized and the base of the searchlight contained most of the control gear, which ensured that once the crew of the Sound Locator were on the sound of an enemy plane, then with a correction for the lag of sound, - see sketch – the searchlight automatically tracked the plane itself and illuminated it. The local A A guns were on it without delay.



Sound lag.

The arc lamp was our long trouble, but of this later. Since the searchlight controller was not, by hand, guiding the searchlight he was seated quite high up on a trunnion arm mounted chair. Among other controls he had the on-off switch for the arc lamp and he sure knew where the defocusing lever was.

The Arc Lamp for the 150 cm searchlight. 75 volts, 150 amps

A word to young designers – when doing the general arrangement drawing, for use by the detailers, please draw the job placed in the direction it works. When tracking, the searchlight is positioned just each side of position (b) shown in Fig. 33. It never works (except for battleground duty) as shown in (a).

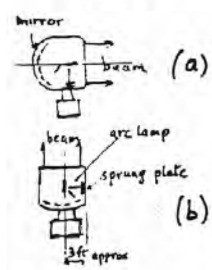


Fig. 33 "don't do it"

Look at the arc lamp in (b) – all the lamp wants to do is to dip towards the mirror. And it did to the tune of 5/16 on an inch! So the beam was always defocused and useless. Jack Dodds believed in tubes for rigidity so the main column as designed by the War Department was discarded and a good 3 inch tube substituted – splendid. No deflection due to gravity. The spring plate was redesigned and all was well. The beam was but 120 feet in diameter at 2 miles!

The principle of the arc is shown in Fig. 34. The sphere (sometimes quite oblate) is held in position in the crater of the positive carbon, rather precariously, by the flame from the negative carbon. Just behind the crater was a horse shoe shaped magnetic plate which, with its magnetic field, steadied the flame, but to keep it from burning up in the incredibly fierce heat surging from the crater another plate of high nickel steel (and high melting point and non-magnetic) was mounted in front of it. In the field it did not work too well so Ingram and I worked on an amended design and finally chose Dunkirk weekend to travel to Christchurch to get it approved. My God, what a journey back to Birmingham via Chettanham around the (temporary) human ruins of the British Army – and the Poles and the French! At 3 a.m., three miles from our homes, we were stopped and searched by the police!

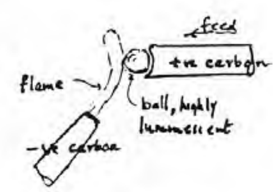


Fig. 34 The arc

Carbons: 16 mm dia.
+ve, 16" long
-ve 12½" long.

I think you can see from Fig. 34 why Michael Faraday could not use the arc lamp of his day when it was at the focal center of a lighthouse optic. But, by adding certain salts to the carbons, salts that burnt in the flame, the brightness of the flame was tremendously increased. You will note that for a searchlight the negative carbon is tilted so that it does not obstruct the light from the crater to the mirror. With a flaming arc the carbons will be in line.

Performance of the Arc and the Mirror

Dr. Hampton's paper to the Illuminated Engineering Society, November 1937 gives, in the discussion, heart rending accounts from members at the War Department and in industry of the fickleness of the atmosphere with its ever changing value of light transmission when the exercise is to measure the candlepower of a mirror, particularly one used in a searchlight. Dr. Hampton, in turn, said that when testing mirrors for Air Route Beacons indoors in Chance's dark room, that the slightest movement of the testers resulted in wild results.

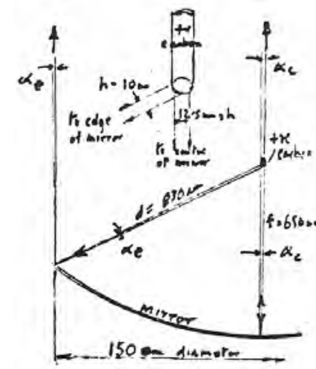


Fig. 35 - divergences.

One member said that when testing a searchlight beam across a valley it was found that the dust caused by the workers going to, or leaving, their work so affected the results that abnormal measurements were recorded. You will recall the difficulties experienced by Dr Hampton's staff when testing fog signals.

When the War Department said 200 million candlepower for the 90 cm searchlight and 500 million candlepower for the 150 cm, you may be sure that, based on many hundred measurements, they were playing safe!

Shape of the beam from the searchlight mirror

In marine work we have not bothered about changes of, say, horizontal divergence of the beam across the width of an optic or mirror, the varying widths or aspects of the flame or filament, and also the varying distance from filament to optic or mirror surface. However Fig. 35 shows for the 150 cm mirror, changes from 12 mm to 10 mm in flame (or rather 'ball') width and from 650 mm (the focal distance) to 830 mm at the edge of the mirror.

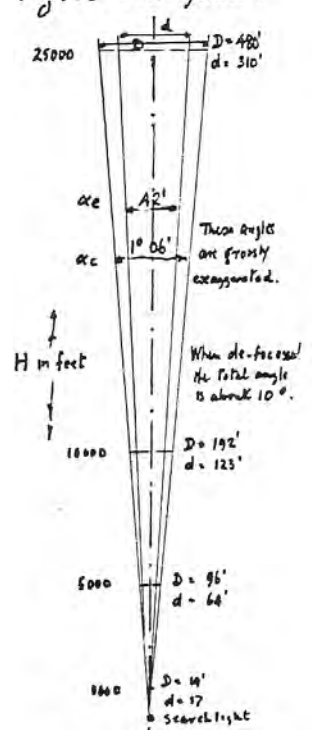


Fig. 36 - the beam

Divergence of the Beam

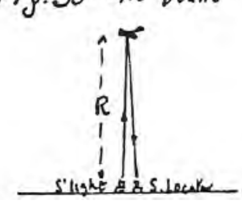
At the center of the mirror the divergence is: 1º 6' with a flame diameter of 12.5 mm and a focal distance of 650 mm. At the edge of the mirror the divergence is: 0º 42'.

Both are very small angles; in fact at a vertical height of 5 miles the 'central' diameter of the beam is but 300 feet. See Fig. 36.

At this stage we might recall that this exercise is not to enable the enemy pilot to see the searchlight, but to hope that a minute amount of light will be reflected back to the central operator on the Sound Locator with his powerful night glasses. The night bomber will be painted a matt black, which is not a powerful reflecting surface!

Light losses incurred within the searchlight are: 9% in the front sectored glass, 9 % for obstruction by the arc lamp, and 15% loss in the mirror itself.

Range (R) in feet: See sketch



The contrast between the color of the target and background is important together with the angular size of the target. For Example:

In a blue sky at dawn, the Moon with a contrast of, but 2:1 is clearly visible whereas Venus at 12:1 quickly fades.

Table 1 is extracted from a paper by Dr. Hampton to the Physical Society in September 1933:

Area of target in sq. feet	Transmission %	Candle power in millions.	Range (R) in ft
200	95	500	50 000
	95	200	38 000
	50	500	11 000
	50	200	10 000
100	95	500	25 000
	95	200	23 000
	50	500	11 000
	50	200	10 000
25	95	500	17000
	95	200	16 000
	50	500	8000
	50	200	7000

Table 1 **Range of Beam**

Findings:

1) The range of the beam is more nearly independent of intensity as the transmission decreases.

2) Range increases as the area of the target increases, provided that the target is small enough to be considered as a point source.

3) An increase in intensity has a decreasing effect on the range as the intensity increases.

Points 1) and 3) are familiar to us from our study of marine lighting.

Photometry of Searchlights:

From a paper given to the Illuminating Society by Dr. Hampton in November 1937.

Outdoor values: The night was hazy and three ranges of 177, 300 and 1125 feet were used for the illumination readings. After corrections for voltage variations, the values were:

Range	177 feet	Candlepower	1,075,000
	300 feet		1,086,000
	1125 feet		1,108,000

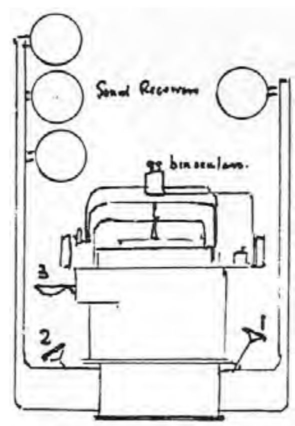
Mean value 1,089,000 candlepower

The data: Measurements were made on a 16 inch (40.6 cm) searchlight mirror with a 30 volt, 900 watt lamp. The filament-grid was 14 by 12 mm with the candlepower normal to the filament plane of 2050 candlepower. This gave a guaranteed candlepower of 955,000 and our mean observed value of 1,089,000 met the guarantee with the usual + 10% margin.

Sound Locater:

I was convinced that this equipment would never reach the field of battle. Rumors had it that the 'black boxes' (of radar) would soon be fitted to the searchlights. But, now read on:

Poor Cuckoo – this is an extract from "The Flames of Calais" by Airey Heave, 1972. "Orphanage farm was in flames when I received an order to send the men into Calais by lorry and remain at Coulonge to blow up 'Cuckoo'. This was the code name for the experimental sound location equipment, which the 'searchlights' had begun to use and it stood on a trailer in the center of the village. It was on no account to fall into German hands. For the next five minutes I was in a delicate position with Sergeant Maginis, and a sapper, as we tried unsuccessfully to blow it up. While the German infantry came over the ridge, too huge French aviation tankers appeared. Their drivers ditched them and set the fuel on fire so that a colossal cloud of thick black smoke covered the village and hid our retreat to Calais. The 'Cuckoo' providentially exploded and groping we escaped to the main road".



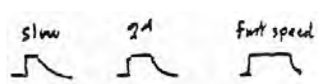
No 1 - Elevation No 2 - Bearing
No 3 - the controller
Sketch of 'Cuckoo'

As far as a detailed knowledge of 'Cuckoo' is concerned, I feel at this point in time, like Robert Browning when Elizabeth Barrett confessed that she did not understand one of his poems. Browning read it again and again finally remarking "that when he wrote it, God and he understood it, but now, God only knows!

Both sound locater and the control gear, to be fitted onto the 150-cm searchlight, were War Office designs, and we just had to mate them. One look inside the locator - a network of gears, spring drivers, solenoids etc. etc. – proved that only the mechanical engineering professor who designed it knew how it worked. It was a secret then, let's leave it so now!

The four large parabolic sound receivers were quite impressive as were the crew of three. The 'bearing' man turned the outer shell round: the 'elevation' man turned the receivers up and down and the 'controller' with his eyes on the very large binoculars; off and on, pressed various switches and fed in the estimated target speed. A vital component had to be laid parallel to the course of the target. The two listeners had stethoscopes, but when I tried them I was amazed how much I breathed out and, through the ears, the awful rushing noise it made. Having secured the stethoscope 'balls' into my ears to stop this, I could, after five minutes, have screamed with pain!

Rather mysteriously the first job of wiring up the control gear, we had made in Engineering Department, to the searchlight, fell to Ingram and myself. I suppose because as senior staff we were prepared to work two days and a night, sustained by beer and chips, to have the equipment ready for inspection by the Royal Engineer Board. So we had to understand at least the control gear (for synchronization with the sound locator) and the three-speed chopped-D.C. motor drives. It approached the real world of 'Alice in Wonderland! We finished about 3 hours before the Royal Engineer Board was due to arrive with one mistake. When the sound locator moved up the searchlight moved down: One minute to correct.



'Chopped D.C' for 3 speeds.

The drill was that our director would take the Royal Engineer Board to lunch and then bring them down to us, but about an hour before they took lunch Ingram doing a three man job on the sound locator and me on the high seat of the searchlight, engaged in a final test and promptly 'hit it bad'. The chopped D.C. (see sketch) slightly vibrated my chair or seat, but after about a 40º bearing change, this died away although the driving continued! "Stop! Check synchronization". Way out!!

Two snags a) after nearly 48 hours of continuous work we were out on our feet and quite incapable of analyzing for a very queer fault, the fiendishly difficult central gear and b) – here I write as a mechanical engineer – that electrical faults seem to be immersed in a shoal of 'red herrings'. They were!

First a phone call to Major Gubbins, our Director, to beg him to give the Royal Engineer's a long and 'wet' lunch – and not to let us see them before 1:30 pm! So we delved into the impulsers, the repeaters, the transmitters, the speed controls, the 'M' motors, etc. etc. (many in duplicate for "bearing" and 'elevation'). Every time we had to synchronize a 4 step procedure!

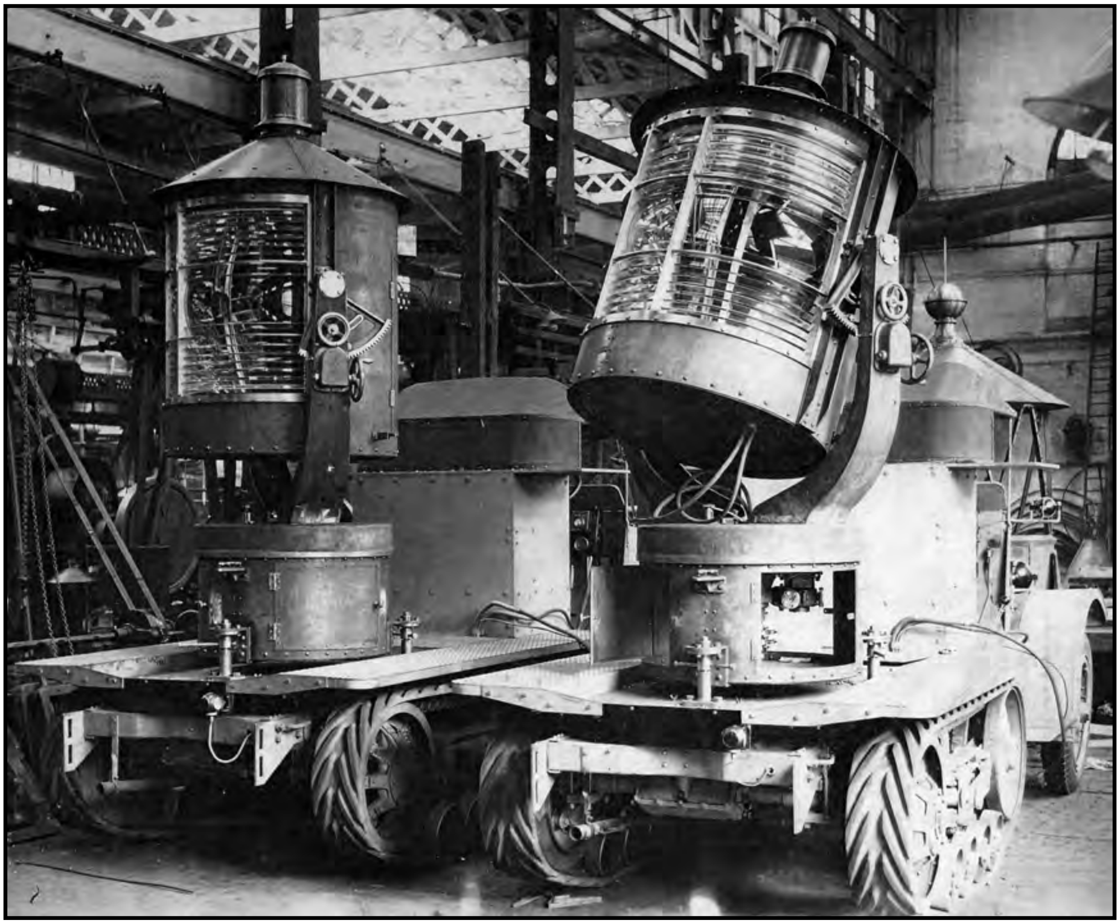
At 1:20 pm I was head down in the bowels of the searchlight- nearly asleep – looking at a nest of circular slip rings with a hand lamp, when I got a glint of light from between 2 slip rings (they were only 3/32 apart). A piece of steel cutting, produced by the makers machining the trunnion housings, was jammed between 2 rings – it had fallen about 6 ft! I hooked it out; synchronized: and a wonderful vibration through 'me seat'. Phoned Gubbins; received the Royal Engineering Board; Board delighted: suggestion we display it to our workers (one of those morale boosting ideas) one night; we could proceed to manufacture; Ingram and myself could go home to our wives, a good meal and a soft bed! In view of this episode I ask leave to finish this chapter and this wee book with a few searchlight tails.

The Christmas card: received by Jack Dodds, from REME, during "searchlight time". About a 2 ft square, beautifully drawn and illustrated 'skates and ladders'. Samples: Chief Inspector arrives, go back 10: Correct material arrives, forward 4: the 20th amendment to the design arrives – go back to the beginning and so on. Many years later I joined a Governing body at a Poly. After three meetings got the name of the member on my right, so passed him a note saying how nice the Xmas skates and ladders had been. He was the culprit.

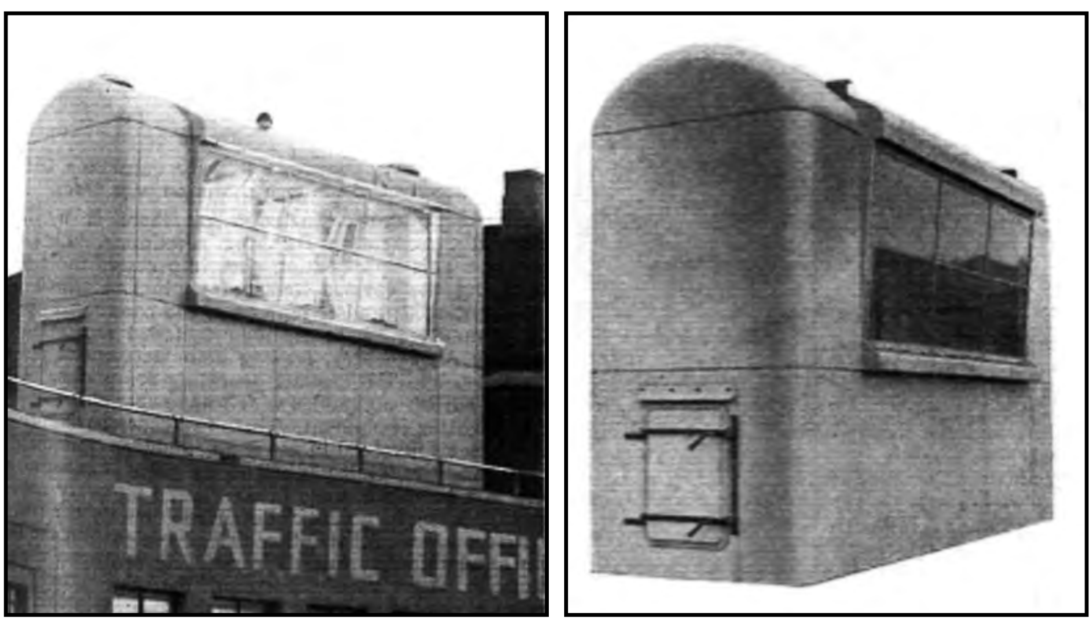
The Norfolk Broads.
Phil Robinson, the Electrical Foreman, Ingram and myself travelled to the East Coast to inspect and pick up the first 150 cm searchlight. We were joined at the works by a REME Chief Inspector. The first session ended in late evening so we drove out to a Hotel alongside one of the broads, there to celebrate our 'War Effort'; we got back somehow, to the small town about midnight, only the Chief Inspector desired fish and chips. Believe it or not we find a shop open and left it with hands full of 'fish' and 'chips'. Unfortunately the Chief Inspector decided to climb one of the 'tee' shaped gas lamp standards, to eat and keep his food warm – singing loudly all the time! Why we did not finish in a local lock-up I don't know. Next day the first two hours of inspection was a sore trial for us all!

Two Ripault stories: - (Ripault made wiring harnesses)
I sent Ripault the wiring harness (designed by the REME) without looking at it. Shortly after a 'phone from Ripault's – this'ere 90 cm harness. "Have you never heard of red, white, blue, yellow and black colors? The drawing shows pink, mauve, orange and the like. You must change it immediately." Me – "can't, may be other manufactures and what about the War Office. instruction manual – may be printed!" Me, again "Am going down to Biggen Hill tomorrow – will phone'em now and say must meet the designer of the searchlight – and he must decide". I met him, he looked every inch a gentleman farmer, but he had a high reputation. "I borrowed the color system." Says he "You wouldn't know but I'm also a scout master and these are our colors!" O'gee O'my! He changed'em.

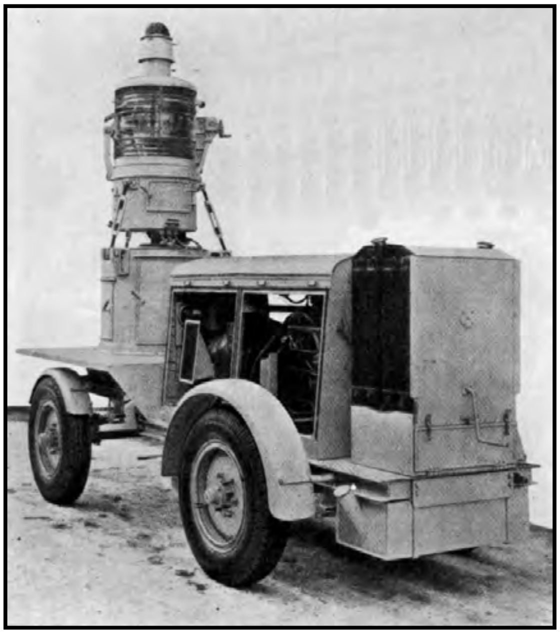
The 150 cm searchlight. I have described above our heroic endeavors in wiring up. One day my first job was to draw the wiring diagram which was pretty intricate. So we decided to tidy up the screaming miles of wire and bind it up as a rough harness, it looked even worse with loops of unwanted wire everywhere so we cut them off. Two days later a slightly irate Ripaulter, "Most amazing harness we have ever seen, we always check continuity. Return to terminal, but got no throughput of current for half of them." Me – I slyly explained our cutting up process and advised him not to worry.



(Photograph Courtesy Association Of Lighthouse Keepers UK)
Number One Portable Floodlight with Tipping Trailer.

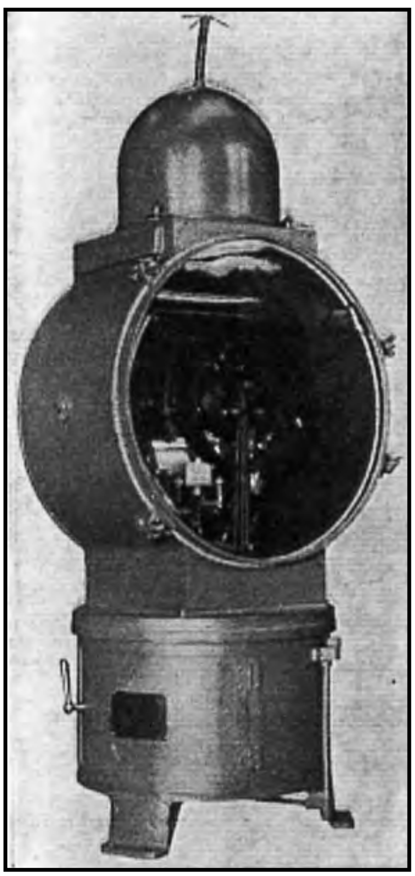


(Photographs from Author's Collection)
Three Position Floodlight in Laminoid Housing (See Fig. 1).

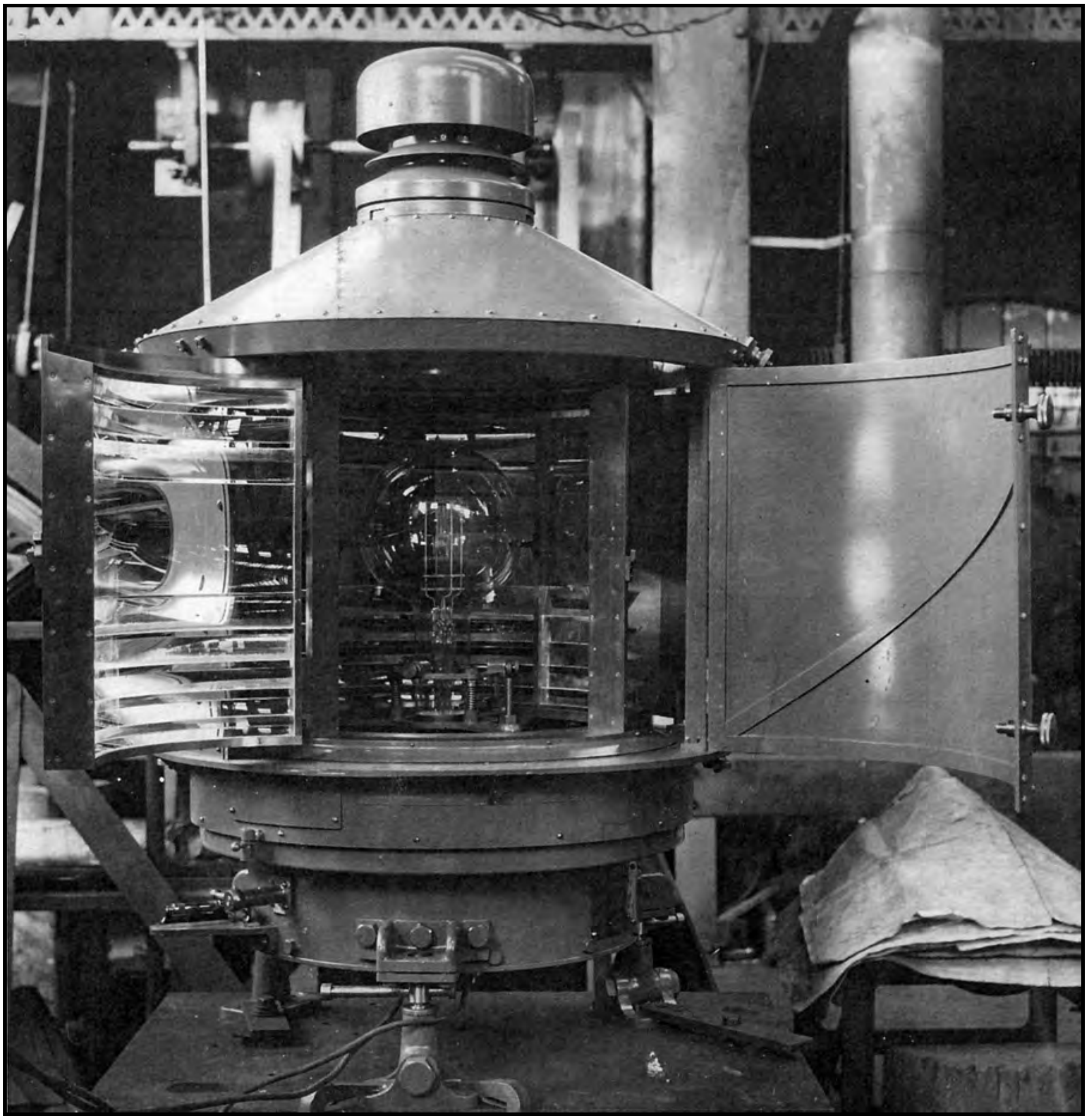


(Photograph Courtesy Association Of Lighthouse Keepers UK)
The Mobile 5 KW Floodlight – Beacon (See Fig. 4).

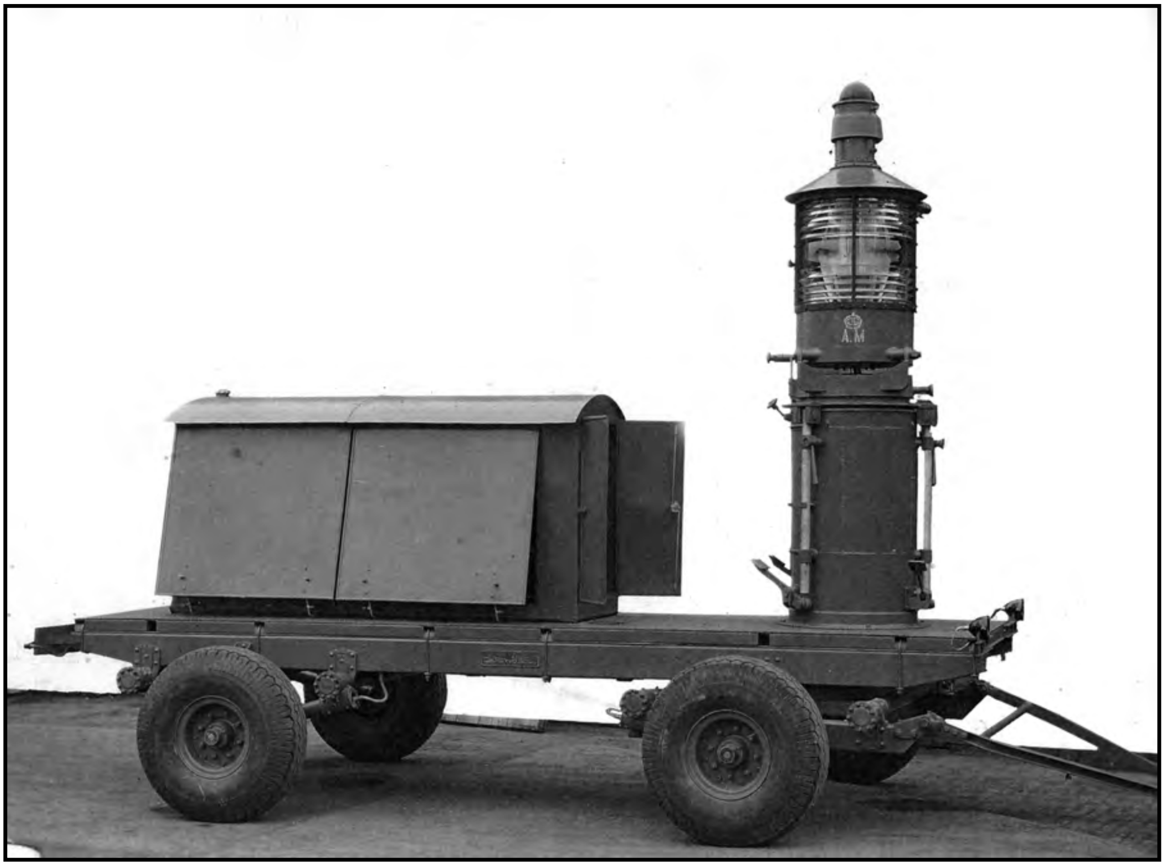
(Photograph from Author's Collection)
The 1½ KW Airway Beacon (see Fig. 8).



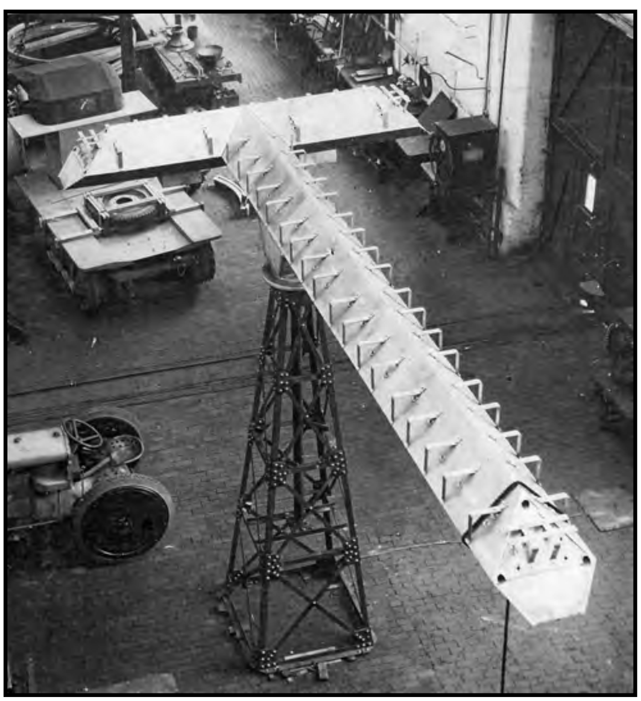
(Photograph from Author's Collection)
1 ½ KW Reflecting Beacon (See Fig. 12).



(Photograph Courtesy Association Of Lighthouse Keepers UK)
The Air Ministry Aerial Lighthouse (See Fig. 17).

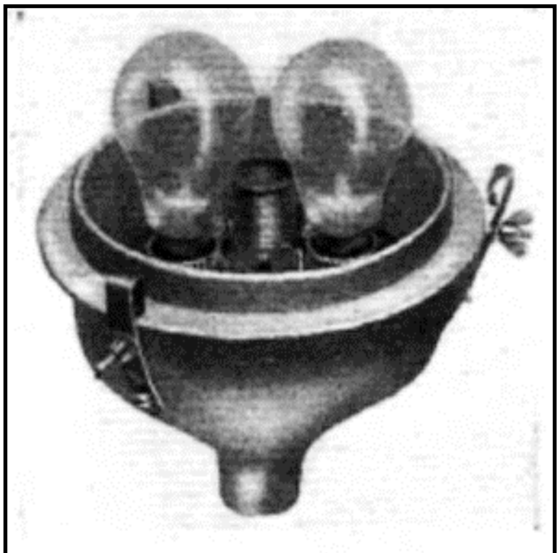


(Photograph Courtesy Association Of Lighthouse Keepers UK)
The Air Ministry Aerial Lighthouse MK III (See Fig. 18).



(Photographs Courtesy Association Of Lighthouse Keepers UK)
Illuminated Wind Direction Indicator (See Fig. 22).

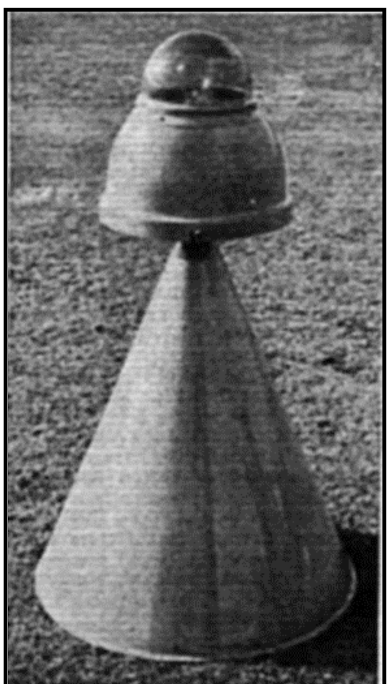
4th Order Aerodrome Lens.



The Chance Brothers' obstruction light has two lamps ; should one fail the other is switched on by a solenoid.

(Photographs from Author's Collection)
Obstruction Light (See Fig 28).

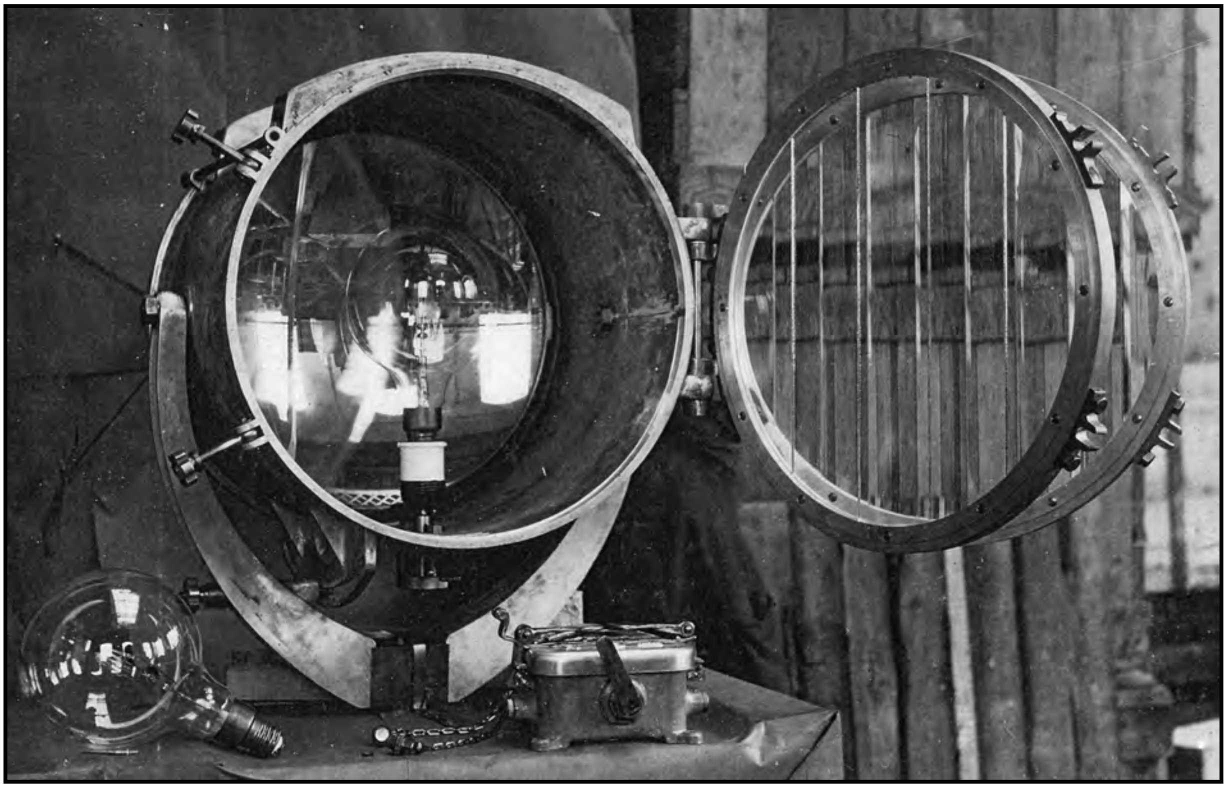
Aldis Hand Signal Light (See Fig. 31).



The latest type of boundary light produced by Chance Brothers.

(Photographs from Author's Collection)
Boundary Light (See Fig. 29).

Boundary Light in Operation at Night.



(Photograph Courtesy Association Of Lighthouse Keepers UK)
Aircraft Searchlight (See Fig 32).

(Photograph Courtesy Association Of Lighthouse Keepers UK)
Three Tiered Aircraft Lights.

(Photo from Author's Collection)
The Cuckoo Sound Locator.