# A HISTORY

# OF

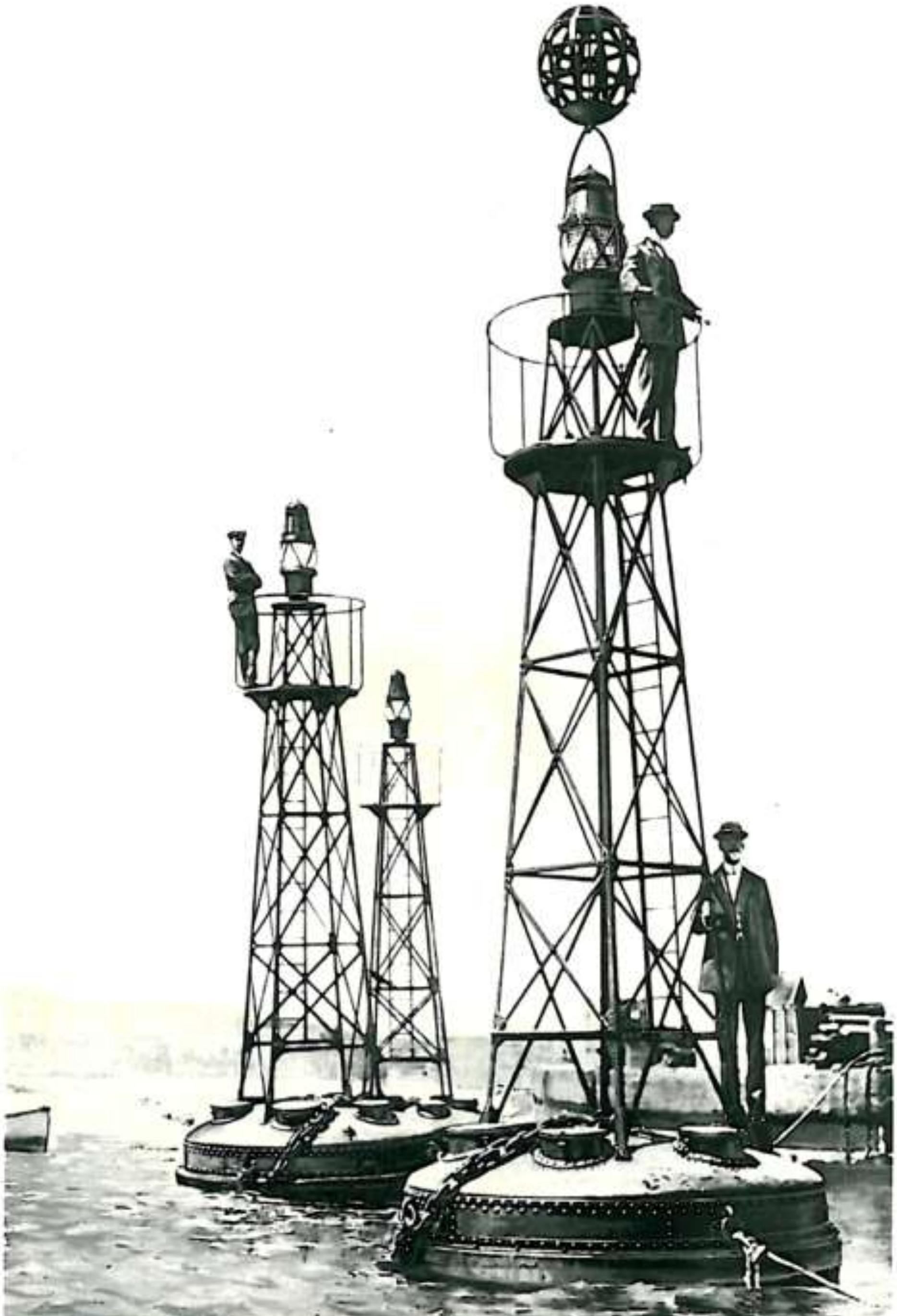
# FLOATING AIDS TO

# NAVIGATION

BARBIER [o.*], BÉNARD * & TURENNE

**PARIS - 82, Rue Curial, 82 - PARIS**

Pl. 836



**Bouées lumineuses à acétylène dissous**
**avec fanaux à occultations et voyants sphériques**

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Adrian Wilkins

*Frontispiece:*
From a Barbier, Bénard & Turenne catalogue c1920 – a charming picture of three very proud gentlemen (Barbier, Bénard & Turenne perhaps) standing on 'Lighted acetylene buoys with flashing lanterns and conspicuous spherical topmark.'

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# INTRODUCTION

I have spent nearly forty years as a professional engineer in the field of aids to navigation and have always been surprised at the lack of written history of buoy and early lightvessel engineering.

Despite extensive research I have been unable to find a definite recorded starting point for the use of floating aids to navigation. The many published histories of lighthouses and lighting apparatus contain very little information about buoys although more information has been researched regarding lightvessels. The 1968 book *The Irish Lighthouse Service* states that '*those who are interested* (in buoys) *probably know all about the subject already*'. This attitude seems to have prevailed in earlier times and the information that is available only informs us of major scientific developments that were incorporated into buoy engineering.

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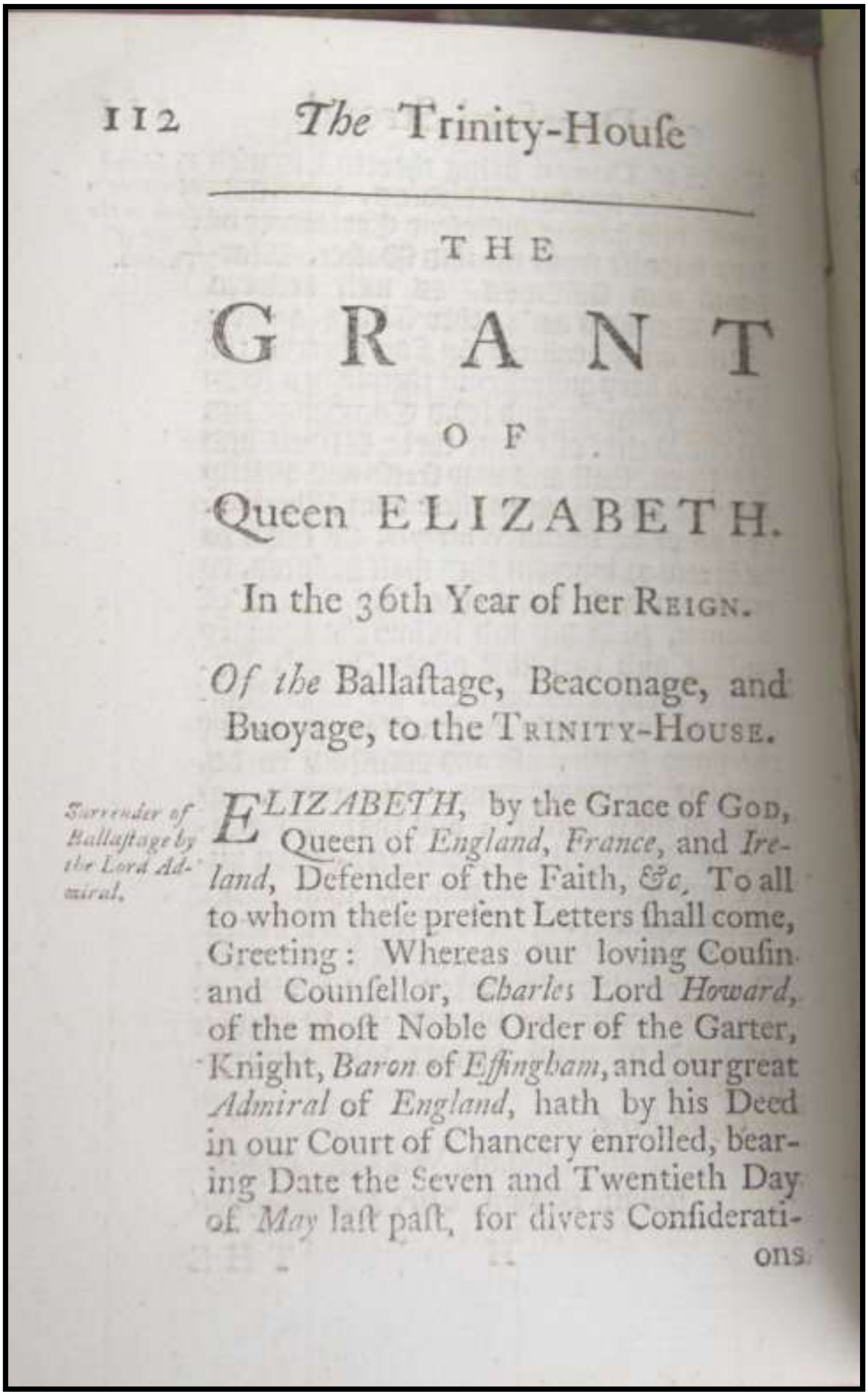
April 2013

# 1. THE FIRST BUOYS

There were probably some forms of floating marks moored to navigational hazards far back in history, possibly simply pieces of wood moored by rope to a block of stone. Anchors are recorded by the Greeks c 500 B.C. (*Anchors* M E Upham) along with mooring chain. Julius Caesar noted that the Veneti tribe in Brittany had iron anchors with iron chains. Both Greek and Roman period anchors had attachment points in the crown, presumably for a cable to connect to a marker buoy.

The first mention of navigation buoys in Europe is generally accepted to be in the Italian sailing directions of 1295, *La Compasso de Navigare*. These mention buoys marking the entrance to the River Guadalquivir, leading to Seville. The buoys were somewhere near Chipiona in the broad estuary that is open to the Atlantic. There is no record of the construction of these buoys or their moorings. Their function was later replaced by lighthouses. Specific records of navigation buoys are found from the year 1300 at Kampen in northern Holland where there are also records from 1334 and mention of a buoy laying contractor in 1399. Sea buoys are referred to in Texel in 1358. The early charters of Trinity House refer to *'Seamarks, Buoyage and Beaconage'*. The following photographs ( Fig.1 & Fig.2) are from the author's copy of '*The Royal Charter of Confirmation* granted by James II to the Trinity House *for the Government and Increase of the Navigation of England 1763*'. It shows a copy of the charter of 1594 from the reign of Elizabeth I showing some of these references.



112 *The* Trinity-Houſe

THE

GRANT

OF

Queen ELIZABETH.

In the 36th Year of her REIGN.

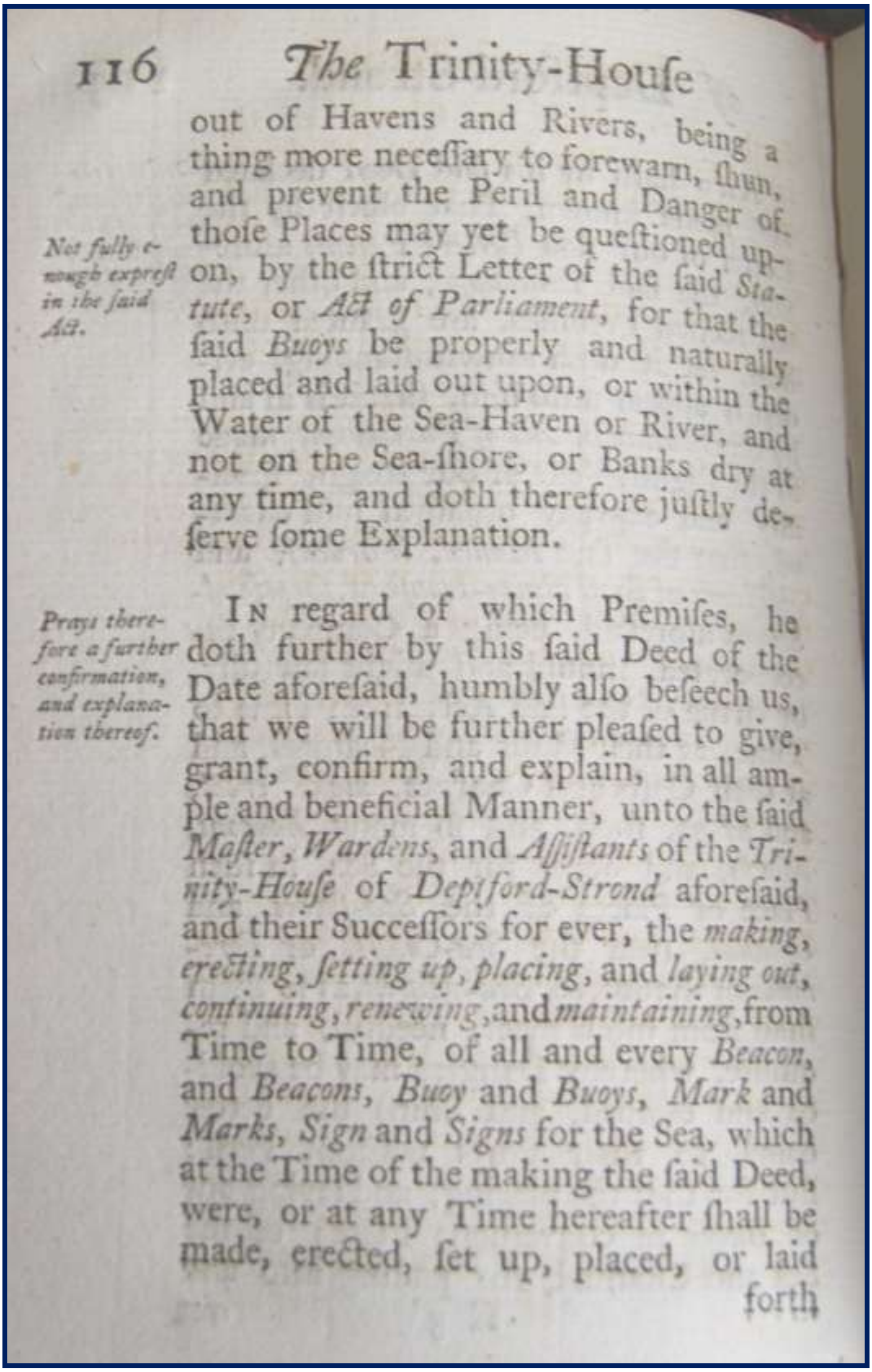
*Of the* Ballaſtage, Beaconage, and Buoyage, to the TRINITY-HOUSE.

*Surrender of Ballaſtage by the Lord Admiral.*

ELIZABETH, by the Grace of GOD, Queen of *England*, *France*, and *Ireland*, Defender of the Faith, &c. To all to whom theſe preſent Letters ſhall come, Greeting: Whereas our loving Couſin and Counſellor, *Charles* Lord *Howard*, of the moſt Noble Order of the Garter, Knight, *Baron* of *Effingham*, and our great *Admiral* of *England*, hath by his Deed in our Court of Chancery enrolled, bearing Date the Seven and Twentieth Day of *May* laſt paſt, for divers Conſiderati-

ons

*Fig.1*


116 *The* Trinity-Houſe

out of Havens and Rivers, being a thing more neceſſary to forewarn, ſhun, and prevent the Peril and Danger of thoſe Places may yet be queſtioned upon, by the ſtrict Letter of the ſaid *Statute*, or *Act of Parliament*, for that the ſaid *Buoys* be properly and naturally placed and laid out upon, or within the Water of the Sea-Haven or River, and not on the Sea-ſhore, or Banks dry at any time, and doth therefore juſtly deſerve ſome Explanation.

*Not fully enough expreſt in the ſaid Act.*

*Prays therefore a further confirmation, and explanation thereof.*

In regard of which Premiſes, he doth further by this ſaid Deed of the Date aforeſaid, humbly alſo beſeech us, that we will be further pleaſed to give, grant, confirm, and explain, in all ample and beneficial Manner, unto the ſaid *Maſter, Wardens*, and *Aſſiſtants* of the *Trinity-Houſe* of *Deptford-Strond* aforeſaid, and their Succeſſors for ever, the *making, erecting, ſetting up, placing*, and *laying out, continuing, renewing*, and *maintaining*, from Time to Time, of all and every *Beacon*, and *Beacons*, *Buoy* and *Buoys*, *Mark* and *Marks*, *Sign* and *Signs* for the Sea, which at the Time of the making the ſaid Deed, were, or at any Time hereafter ſhall be made, erected, ſet up, placed, or laid

forth

*Fig.2*

The first small illustrations of buoys appear on charts around 1500.

*Fig.3* Buoys are clearly shown on this illustrated chart from the early 1500s. They are of conical form.

*Fig.4* Conical wooden buoy showing the arms of Hamburg 1568

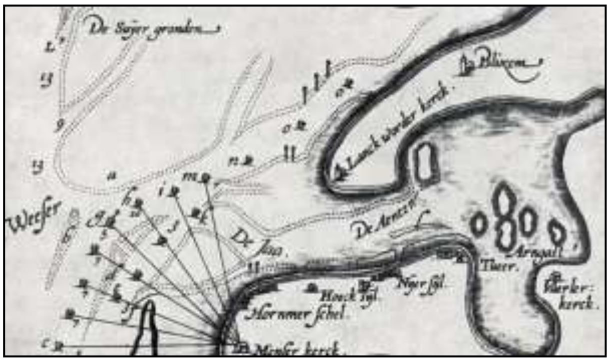


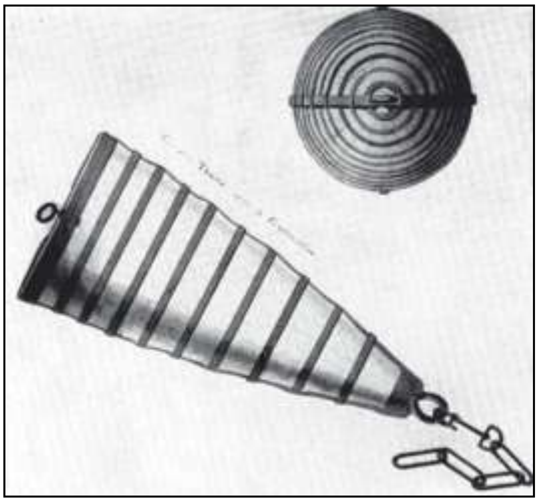
*Fig.5* Haeyen chart from 1585 showing buoys positioned on bearing lines from a church

*Fig.6* Large sea buoys, Hamburg 1675

More detailed illustrations of individual buoys are found in documents starting from 1585. Illustrations spanning three hundred years show a common form of conical buoy made from tapered wooden staves and bound with iron hoops. The mooring was attached to the point of the cone and the flat, circular end was the top of the buoy that carried its name or number. This type of iron bound, wooden construction is similar to that used for making barrels and is, in English, called cooperage. There are also references to cork being used in buoy construction but it is not clear if buoys were made entirely from cork or if wooden buoys were filled with cork to maintain buoyancy in case of leakage.

Some buoys were similar in form to conventional barrels but they seem to have been in the minority.

*Fig.7* A wooden buoy from 1810 with extensive iron bands, long link chain, a swivel and a hook for attachment of the mooring to the buoy.



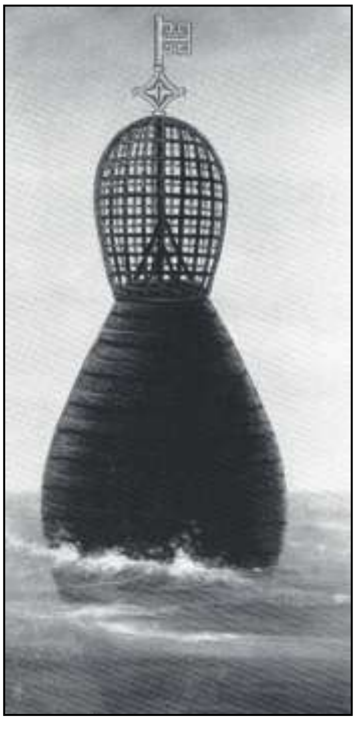


*Fig.8* Biconical buoy 1790

These buoys were also constructed in a bi-conical form, presumably to provide a better daymark.

The technology of wooden buoy construction seems to have developed first in Holland and Germany. It is generally accepted that wooden buoys were manufactured by the same process as barrels were made and there are records of wooden barrel making going back to the first century BC. A German book on cooperage (barrel making), *Die Bottgerkunst* from 1765 makes mention of '*sea barrels'* and this has been presumed to be a reference to buoys. There are records of the Trinity House of Hull (UK) buying buoys from Holland in 1621 and Hamburg in 1682. It would be interesting to know why the considerable expense was justified to import what seem to be very simple products given that the construction of wooden barrels from curved staves was a widespread craft. *A Sea Grammar 1627* by Captain John Smith, a compendium of sea terms, refers to buoys (then spelt boyes) as being short pieces of wood used to mark the position of anchors or *'can boyes'* that were much larger and moored *'to give mariners warning of dangers'*. The term *'can buoys'* could be confusing as illustrations show that this term was used to describe the conical wooden buoys then in common use. This term was still in use in the mid 1800's.

There are references in Trinity House documents to buoys being laid and maintained by local contractors. The first mention of buoys in the Thames' Estuary, *The Trinity House of Deptford 1514 – 1660* G.G Harris, is in 1536; there were seven buoys in 1580 and sixteen by 1684. The only details of the buoys were given in a '*note'* from 1630 that they were '*only square pieces of timber 6 or 8 feet and fastened onto a chain of iron'.* Then in 1742 a '*buoy boat'* was constructed to service the buoys.

# 2. MOORING

Buoys were moored with specially made square stone sinkers or with old, round, worn millstones. There is mention in records in Holland of both rope and chain moorings from 1358 and particular mention of the iron chain links being made from square cross section iron. Some buoys that were only on station in the summer months were moored with rope. By the 16th century many buoys were moored with chain. This is 300 years before chain came into general use for mooring ships. A patent was granted in England in 1634 to a blacksmith Phillip White, for the manufacture of chain cable for ships. Chain cable did not come into general use on ships until the 19th century.
There are references in Trinity House documents from 1677 of *'buoys, chains and stones'*, indicating that chain moorings and stone sinkers were in use.

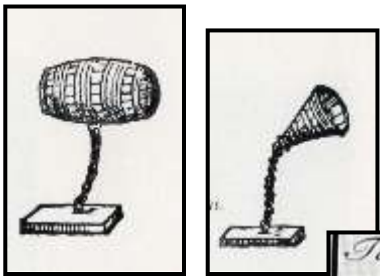


*Fig.9* Small German book illustrations show buoys, sinkers and chain 1585.

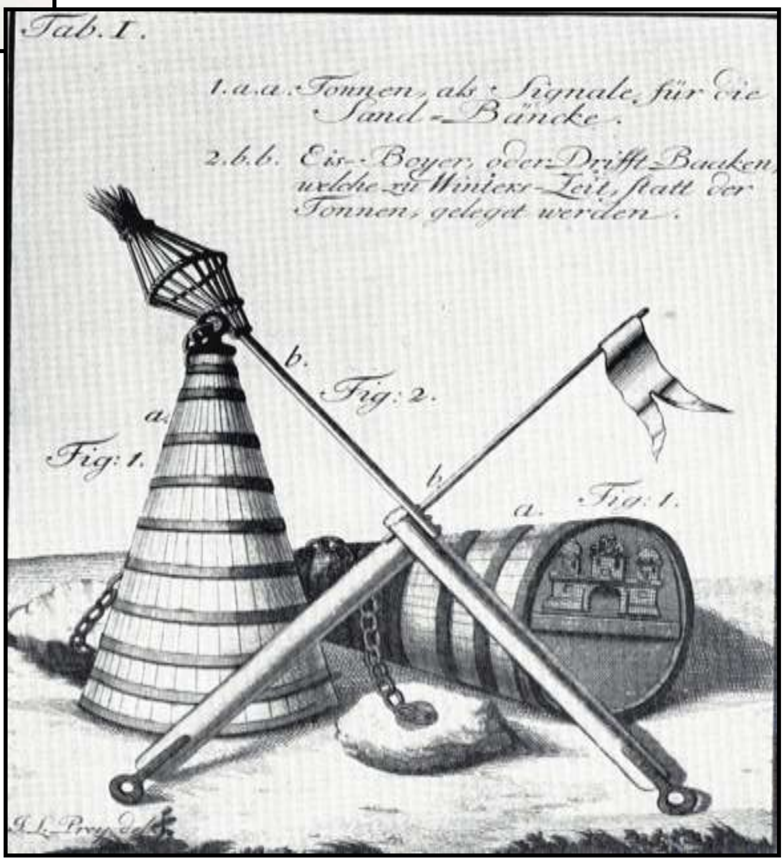



*Fig.10* Buoys, chains and sinkers in Hamburg 1751, the wooden spar buoys with flag and cage topmarks were used during the winter in place of the large conical buoys.

The chain used for buoy moorings from the 16th century was very different to modern chain. It was entirely hand forged and the individual links were generally very long. Port of Liverpool buoys (1794) were moored with chain made from alternate 150mm long oval links and 460mm links of bar with an eye at each end. There is an earlier German reference to 300mm to 500mm long chain links made from 22mm diameter bar.

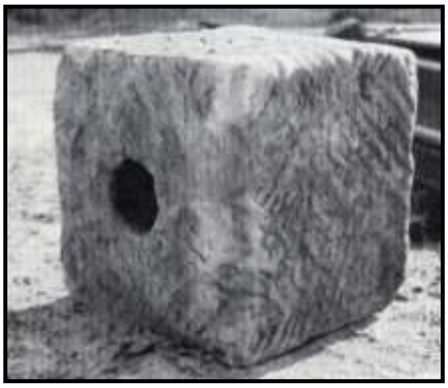


*Fig.11* Stone sinker

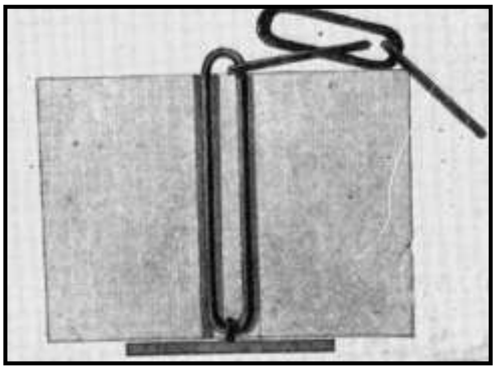


*Fig.12* Sinker with long link chain

Long links provide faster and hence lower cost construction for a given length of chain and reduced the number of welded joints that were the weakest areas of the chain. The welding was carried out by the blacksmith, hammer forging the ends of the bars together that made up each link: a process requiring considerable skill to ensure the strength and integrity of the finished length of chain.

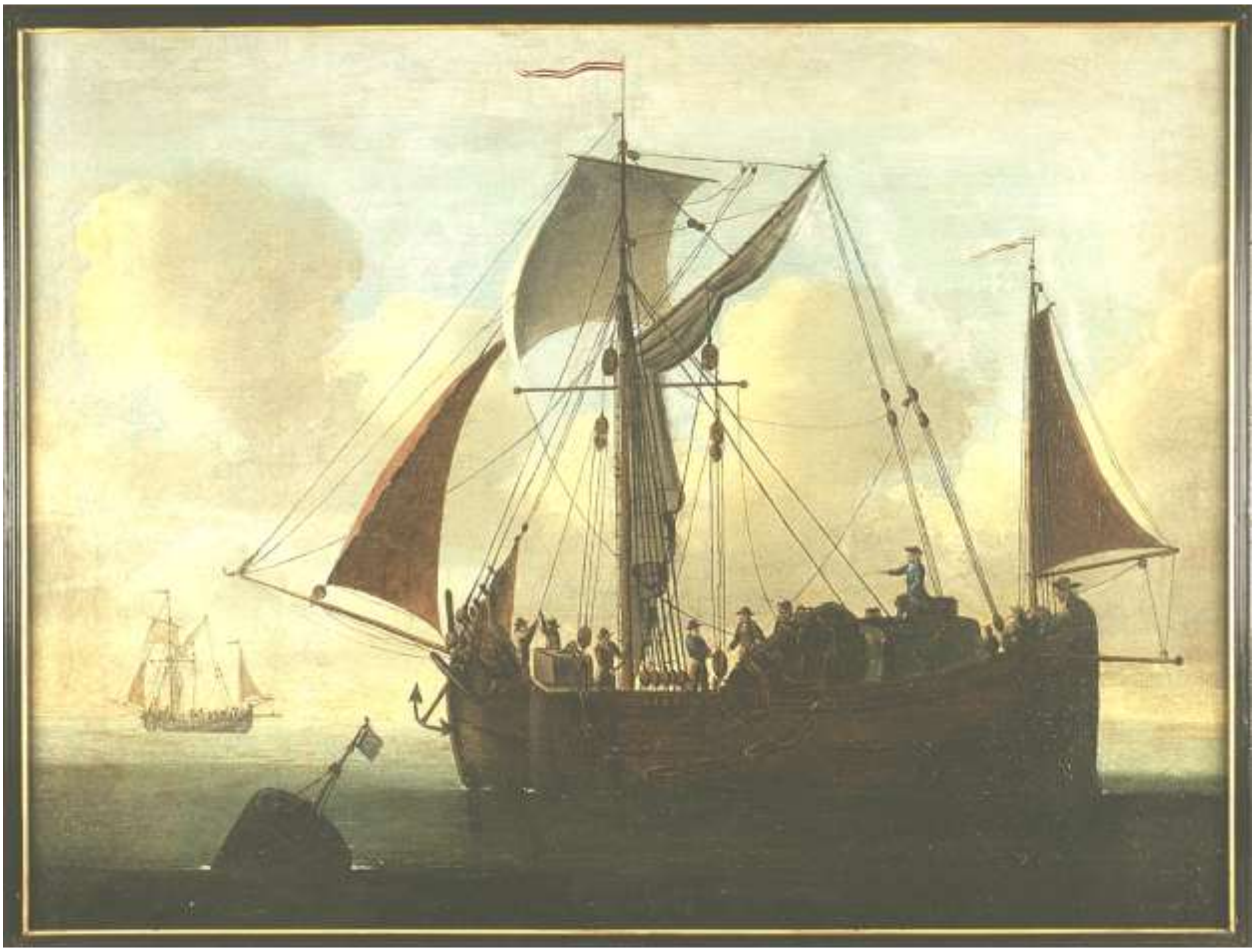


*Fig.13* Bremen buoy tender 1770

The Bremen buoy tender has a conical wooden buoy on deck with long link mooring chain and a large stone sinker. There is possibly a swivel in the chain close to the buoy. A conical wooden buoy with topmark staff and flag is in the foreground.

It is interesting that in the account of the building of the Eddystone lighthouse by Smeaton in 1758, he particularly notes that their use of chain moorings for securing their support vessel was special and unusual at this time. The chain was made for this mooring by a Mr Wilson of Blackwall (London). The difficulties with handling this chain, which had 150mm long links, on board ship, are described in some detail. Trinity House had one spare chain mooring at this time, presumably a lightvessel mooring which they loaned to Smeaton. He mentions that the Eddystone mooring support buoy was made of layers of cork and that swivels were incorporated in the moorings.

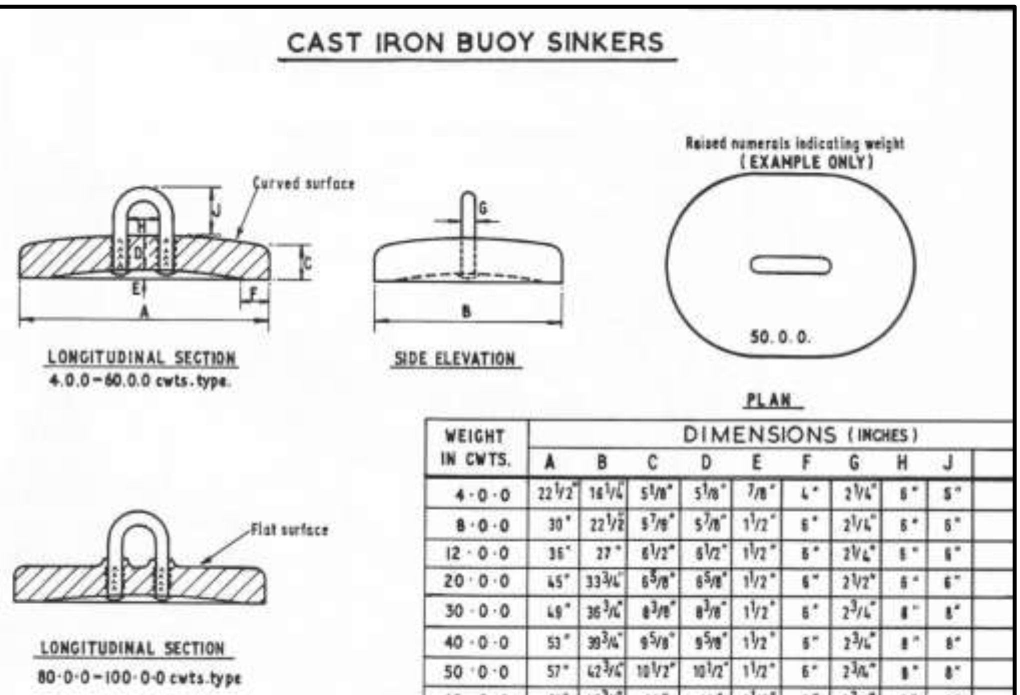
The manufacture of iron chain on a large scale began in England in the early 19th century and had developed into a major industry in the Birmingham area by the 1820s. Manufacturing processes developed in the next century until steel chain was made entirely by machine with the links being electrically resistance welded although hand forging was still used for some mooring components in the 1950s.

Swivels seem to have been included in many early chain buoy moorings and they were certainly used in the 18th century for the attachment of ship's anchors to their cables.

The early drawings of buoys and moorings do not show shackles being used to join mooring components. Figure 7 shows an open connecting hook that was presumably 'moused' (see end of chapter) to prevent disconnection. Other moorings would have been assembled with the assistance of a blacksmith who would hammer weld the necessary joining links of chain.

It is not clear when shackles came in to common use however the use of shackles with oval cross section pins, retained with a split cotter, seems to have been widely adopted by the 1850s.

Cast iron sinkers (fig.14) were used by many lighthouse authorities. There would have been a range of sizes for use at various buoy stations. Some authorities used concrete sinkers; these were cheaper than cast iron but very much larger than a cast iron sinker of equivalent weight.




| WEIGHT IN CWTS. | DIMENSIONS (INCHES) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | J |
| 4·0·0 | 22 1/2" | 16 1/4" | 5 1/8" | 5 1/8" | 7/8" | 4" | 2 1/4" | 6" | 5" |
| 8·0·0 | 30" | 22 1/2" | 5 7/8" | 5 7/8" | 1 1/2" | 6" | 2 1/4" | 6" | 6" |
| 12·0·0 | 36" | 27" | 6 1/2" | 6 1/2" | 1 1/2" | 6" | 2 1/4" | 6" | 6" |
| 20·0·0 | 45" | 33 3/4" | 6 5/8" | 6 5/8" | 1 1/2" | 6" | 2 1/2" | 6" | 6" |
| 30·0·0 | 49" | 36 3/4" | 8 3/8" | 8 3/8" | 1 1/2" | 6" | 2 3/4" | 8" | 8" |
| 40·0·0 | 53" | 39 3/4" | 9 5/8" | 9 5/8" | 1 1/2" | 6" | 2 3/4" | 8" | 8" |
| 50·0·0 | 57" | 42 3/4" | 10 1/2" | 10 1/2" | 1 1/2" | 6" | 2 3/4" | 8" | 8" |
| 60·0·0 | 61" | 45 3/4" | 11" | 11" | 1 1/2" | 6" | 2 3/4" | 8" | 8" |
| 80·0·0 | 66" | 51" | 12 7/8" | 11 3/8" | 1 1/2" | 6" | 3" | 8" | 10" |
| 100·0·0 | 72" | 54" | 14" | 12 1/2" | 1 1/2" | 6" | 3" | 8" | 10" |

*Fig.14*

**To Mouse** – to put turns of small rope or wire round the point of a hook and its neck to prevent unhooking.

# 3. THE FIRST LIGHTVESSELS

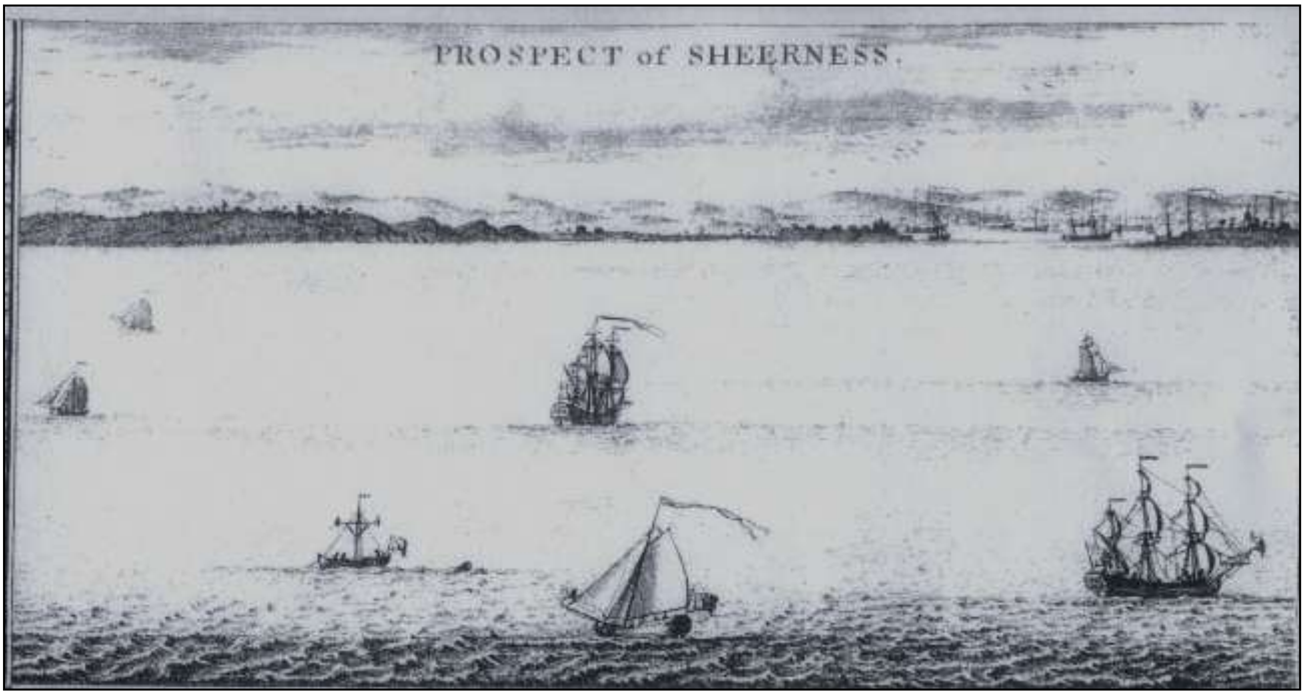



*Fig.15* Detail from 1732 Thames Estuary chart

This is an detail from a 1732 chart that illustrates the first lightvessel established in 1731 at the Nore station in the Thames Estuary near the junction with the River Medway.

Sea trade was increasing and a lighted aid was required to enable ships to navigate at night in the generally featureless estuary of the Thames. The only contemporary method of producing light was by burning some form of fuel and this would require attendants. A small fishing vessel was converted to provide this first lighted seamark where a crew could live on board to tend the lights.

A German website 'Feuerschiff', notes that vessels had been deployed before this time with some form of light on deck to mark harbour entrances but not permanently moored as sea marks.

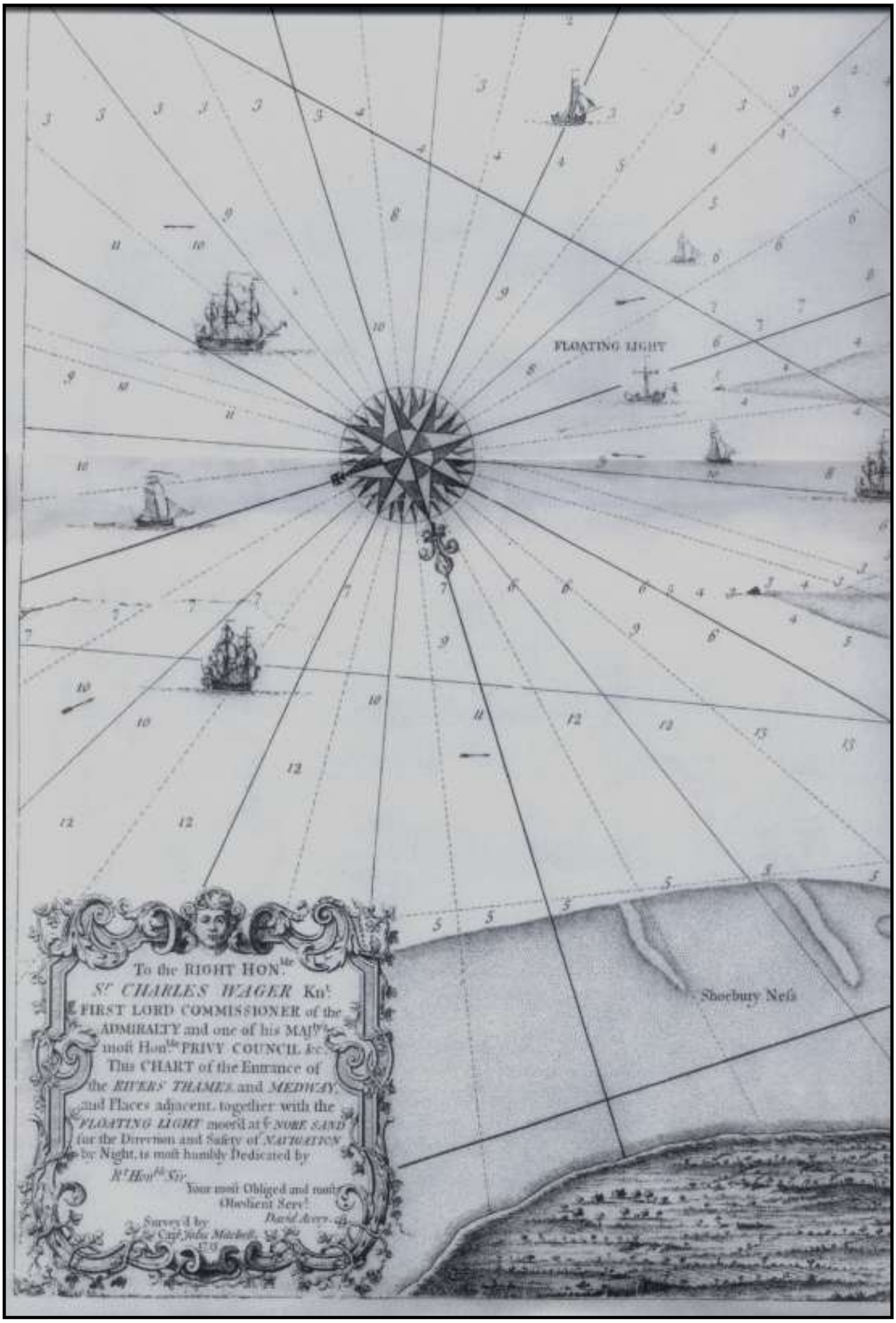



*Fig.16* Part of 1732 Thames Estuary chart. This chart was produced one year after the Nore light vessel was established. The chart also shows one conical buoy.

This is believed to have been an accurate model of the original Nore vessel that set a large flag as a daymark and candle lanterns at the end of the yard at night. The crew tended the rope moorings and sailed the vessel when the mooring failed.

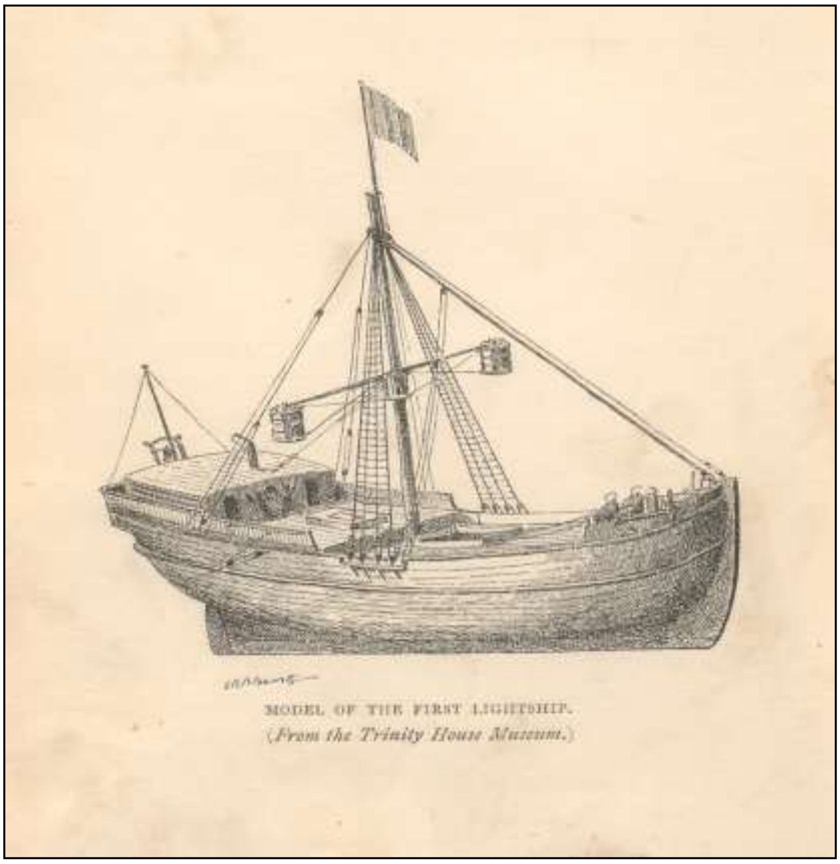



*Fig.17* Model of Nore lightvessel

More lightvessels were gradually introduced as their effectiveness became apparent. The technology of the aids to navigation on these vessels generally followed that used in lighthouses. The size of the lightvessel's hull formed a better daymark than would be provided by a buoy. Lights developed from candles to oil lamps and eventually to electric lights. Fog signals included guns, bells, gongs, rockets and later whistles, diaphones and sirens.

*Fig. 18* Nore Lightvessel in 1830
The lantern encircles the mast and
would be hoisted up the mast at night.

Lightvessel designs were refined until in the 1930s they had rotating lights, diesel generators, compressed air fog signals and radio beacons. The major difference that existed from one country to another was that some authorities had self-propelled vessels and some had vessels with no propulsion machinery and thus had to be towed to station. Authorities with many floating aids to navigation needed a considerable fleet of support vessels to tow lightvessels to and from station, change crews over, maintain moorings and to lay and re-gas buoys.

# 4. THE DEVELOPMENT OF BUOYS

By the 19th Century, commercial ships have become larger, deeper draft and faster. There is the need to identify the deep-water channels and to navigate restricted waterways at night and in poor visibility. Hence buoys have become larger and more numerous. Trinity House had 40 buoys in 1796 and 400 by 1860. Lattice top marks and flags are in use as daymarks in the early 1800s but they are carried on what are essentially the same wooden buoys as were in use 200 years before.

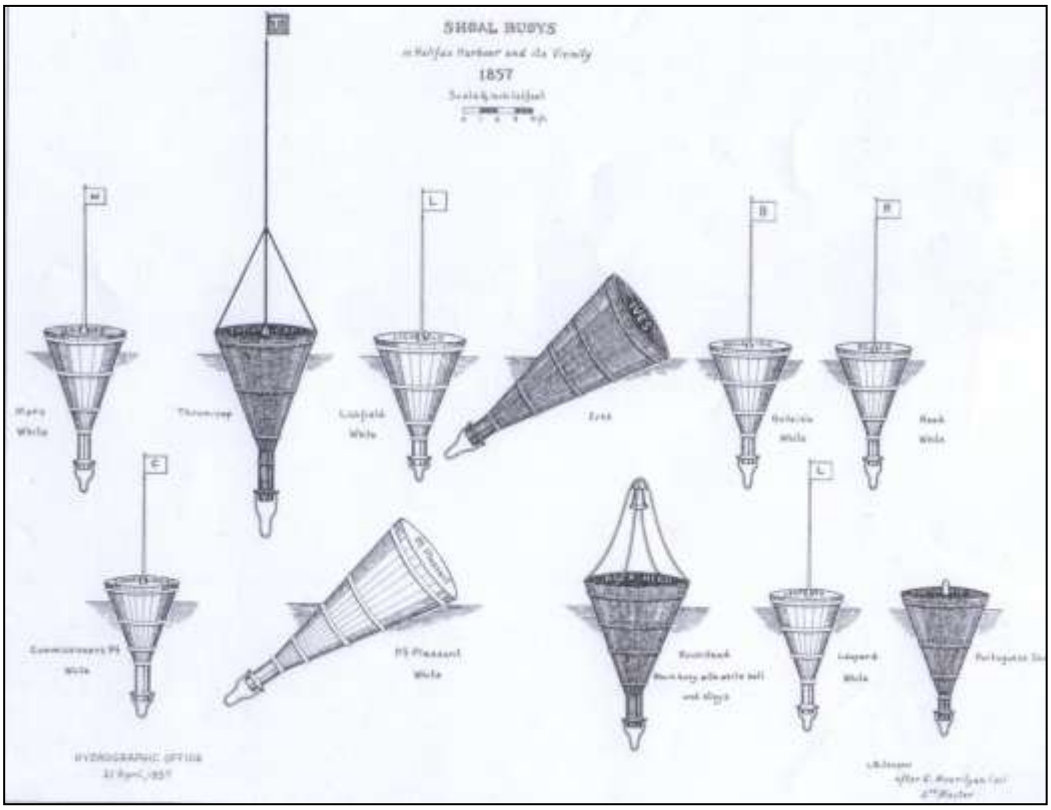



*Fig.19* Wooden buoys with topmarks 1857

As wooden buoys were made larger they had to be made from increasingly thick timber to be sufficiently strong and hence became heavier. Illustrations from this period suggest that some wooden buoys had two layers of external planking and had an internal bulkhead, presumably to prevent the buoy sinking if leakage occurred. The shapes that could be made by this cooperage process were very limited. Some conical wooden buoys were fitted with iron framework supports for topmarks. In the mid 1800s conical buoys were built with mooring fittings on their flat surface so that they would float point upwards, relying on the weight of the mooring to hold them in this position. This provided a larger daymark than the point down configuration.

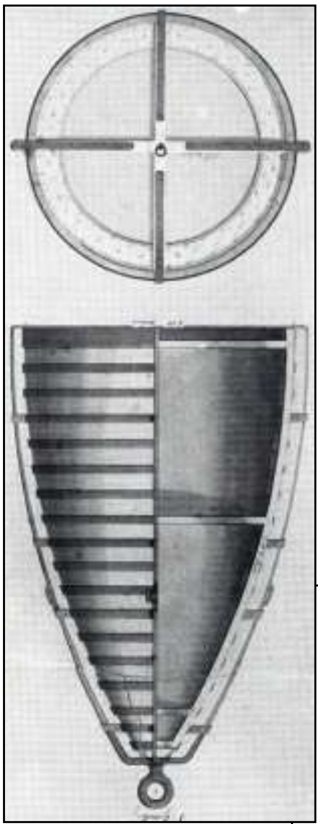


*Fig.20* 1830 wooden buoy with double skin planking and an internal bulkhead

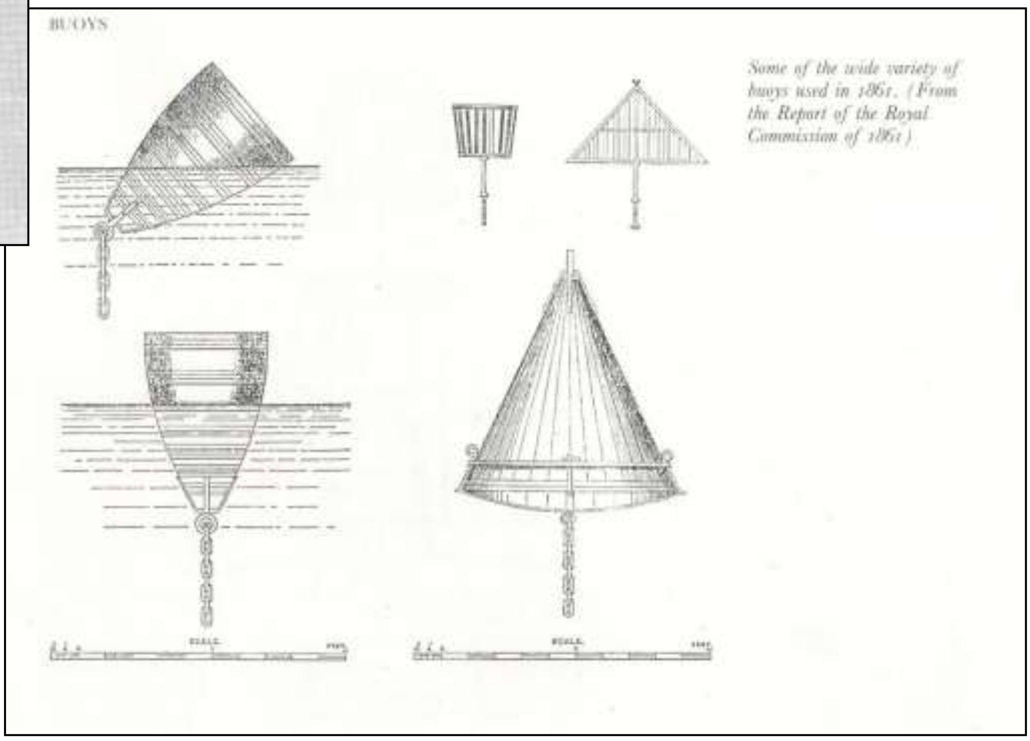



*Fig.21* The illustration from the UK 1861 Parliamentary report on seamarks shows two conical buoys moored point downward and one point up and associated topmarks.

*Fig.22* Poole Museum (UK) conical
wooden buoy with author and companion

Figure 22 shows a medium sized buoy of the type designed to be moored from the flat face. This buoy is of uncertain age and is retained in the stores of the Poole Museum (UK). It stood outside the museum for many years and has been extensively restored.

The reliability of wooden buoys and their moorings was well established by the 1800s. A Royal Commission reported in 1858 that there were 356 Trinity House buoy stations and there were 14 reported incidents of buoys being adrift in that year. At that time there were a total of 1109 buoy stations in the UK which included harbour and river authority buoys. There were 573 spare buoys held by the various authorities.

*Fig.23* Wooden buoy, believed to be Dutch

Figure 24 is a drawing from Holland, showing a wooden buoy modified for use in fast flowing currents by the addition of an iron keel and globe topmark. The inset detail is from an English painting showing a very similar buoy on the Margate Hook station in 1828

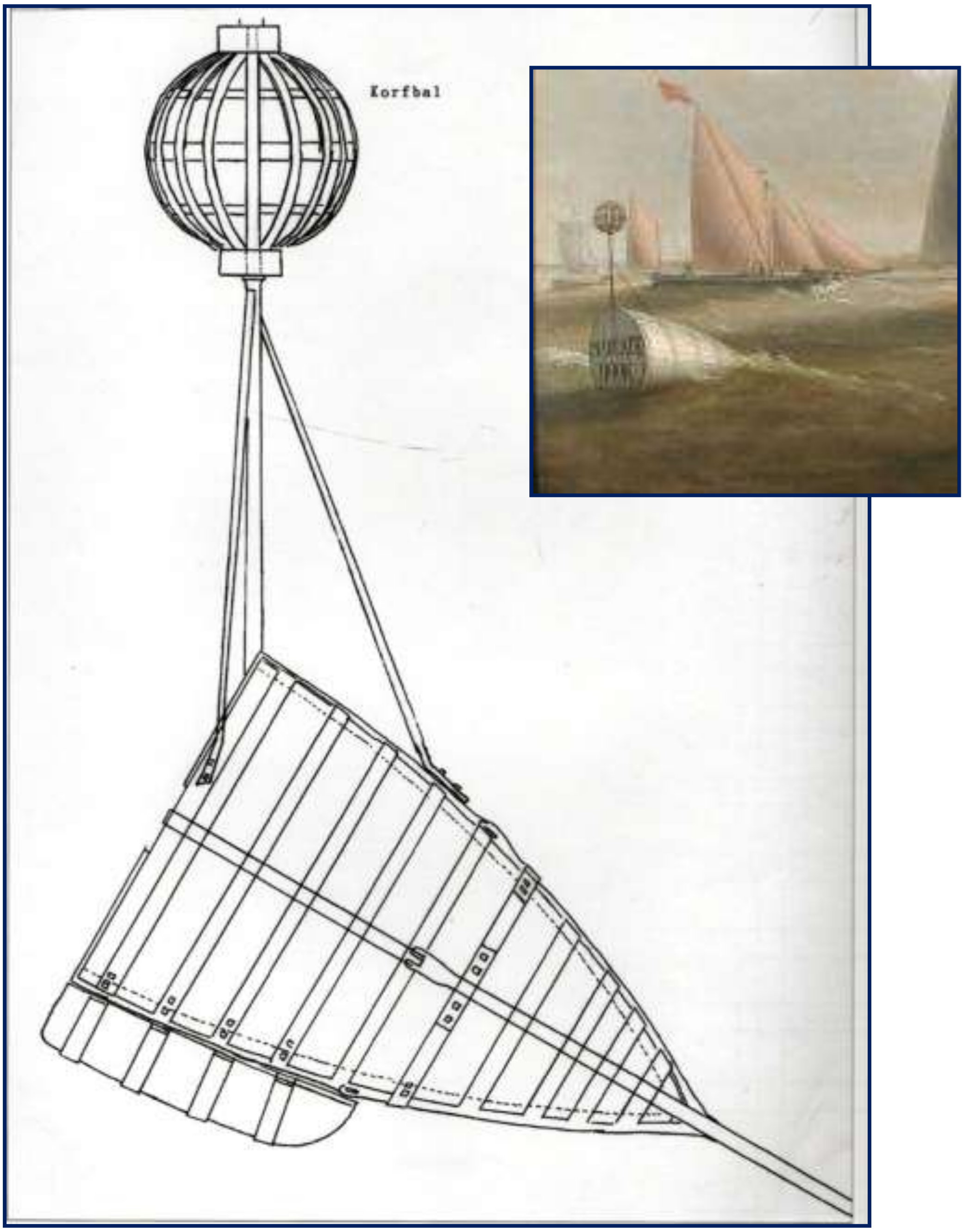



*Fig.24*

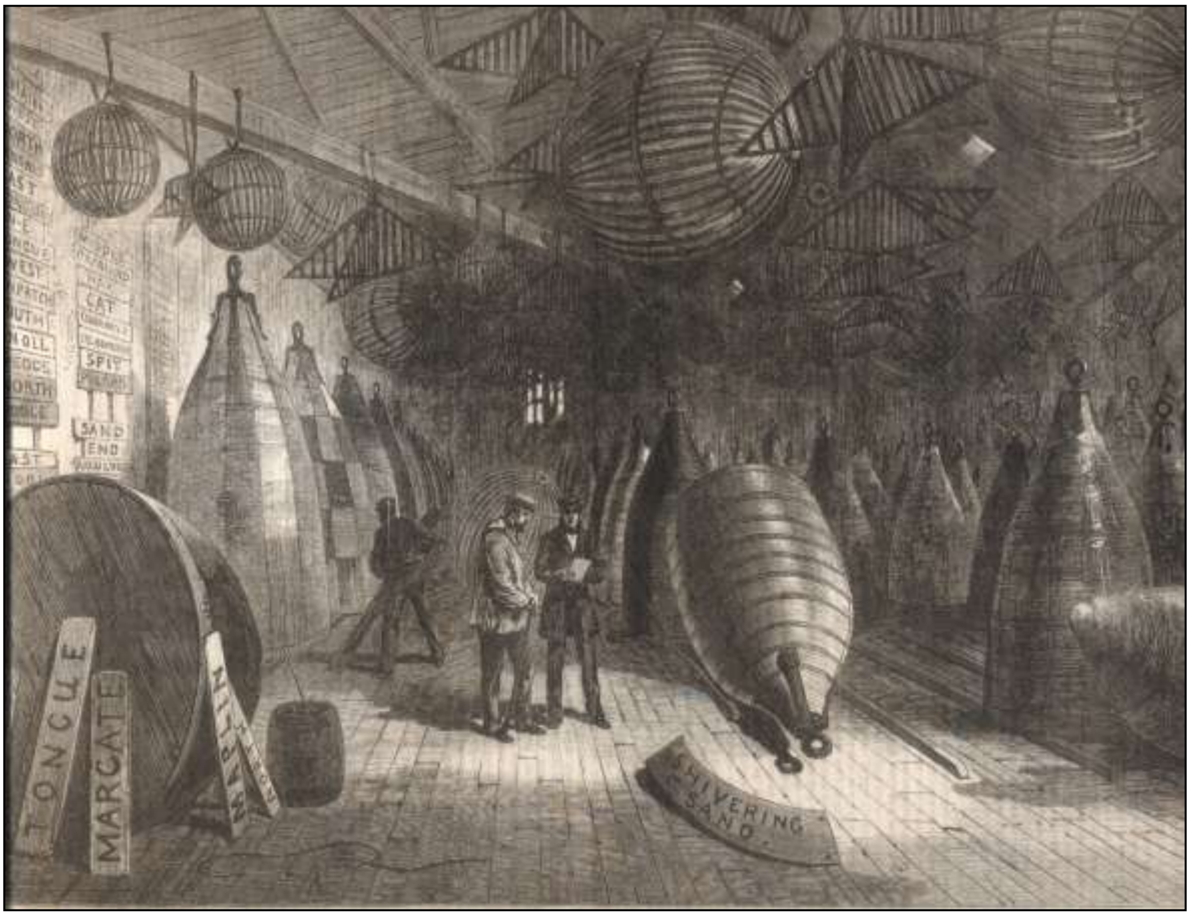



*Fig.25 Trinity* House Blackwall buoy store 1860

Above (Figure 25) is an illustration of the Trinity House Blackwall (UK) buoy store in 1860. It shows wooden buoys, topmarks and name boards, for various buoy stations. At this time the technology of manufacturing iron storage vessels and iron ships' hulls developed at a rapid pace and this technology was soon used to make iron buoys.

The first riveted iron buoys followed the shape of wooden buoys but they could be larger than wooden buoys, providing better daymarks and also support heavier moorings. In the UK the first iron buoy was supplied to Trinity House by Lenox (an iron working company) in 1846 followed by seven in 1847 and twenty two more in the following five years. Designs changed as mooring eyes and ballasting arrangements developed.

The French Service has records of an iron buoy on the Loire River in 1847 and the US service trialled an iron can buoy in 1850.

The ability of iron to be worked into many complex shapes allowed a variety of buoy designs to be developed that, in some cases, incorporated the daymark shape with the buoy body. Iron construction also allowed the buoy to be sub-divided with internal bulkheads maintaining buoyancy in case of collision damage.

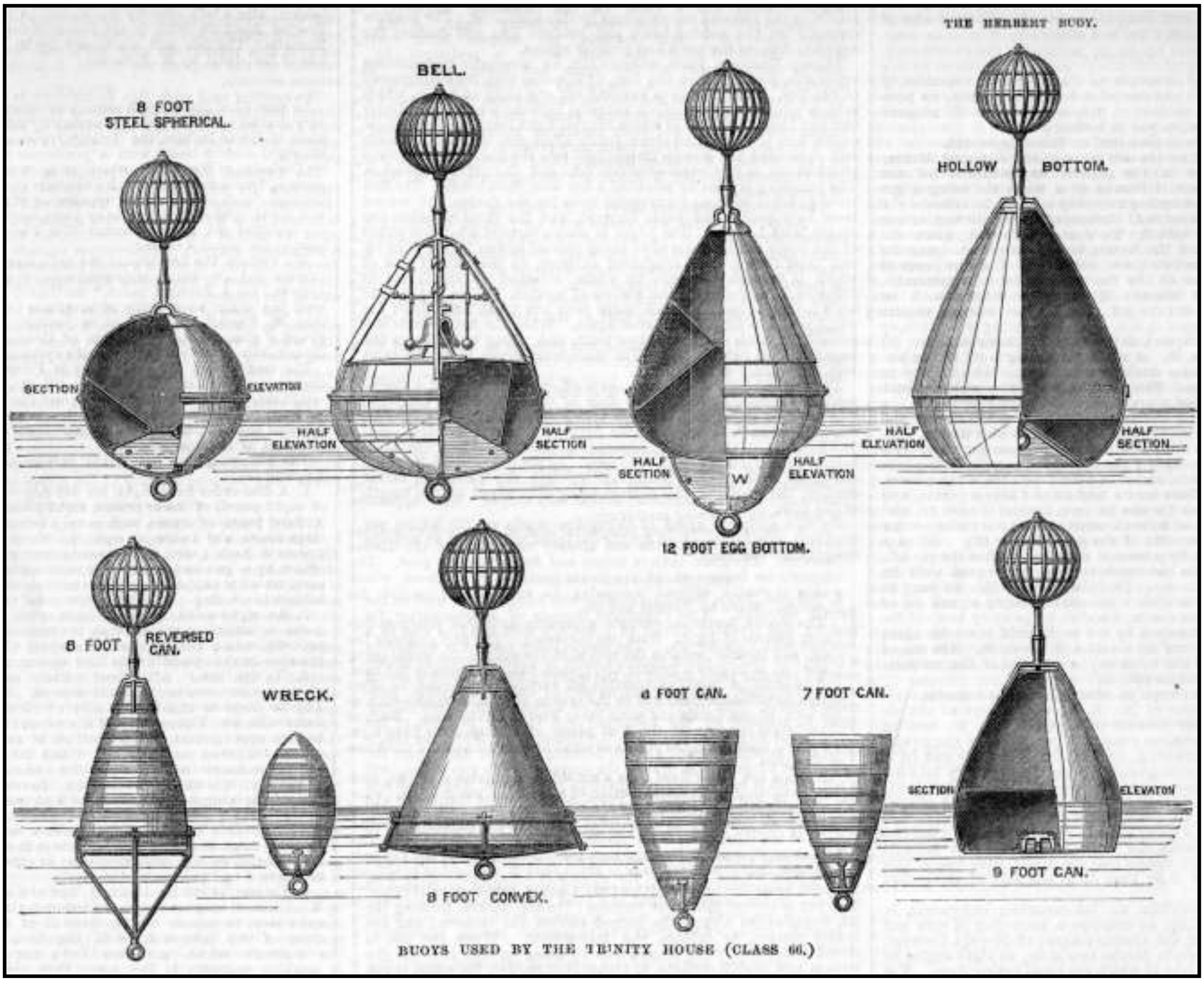



*Fig.26* Illustration of Trinity House buoys prepared for the Paris Exhibition of 1867

At the 1867 Paris Exhibition it was reported that Trinity House had 400 buoy stations. These buoys were placed on station for periods of six months and then returned to the depot for repair and painting.

The bottom left illustration in Figure 26 is a wooden conical buoy moored from the flat surface and fitted with a top mark. This was introduced to improve the daymark area of the buoy but relies on the weight of the mooring chain to maintain stability. The two conical buoys moored from their pointed ends are the standard wooden buoys which were referred to as can buoys. This term is also used to describe the iron conical buoy at the right end of the bottom row.

Note that a bell buoy is included: these quickly came in to use as they provided an audible warning to mariners in conditions of restricted visibility. This particular design also provides the first example of an open lattice daymark.

The half elevations of the first three iron buoys clearly show the internal bulkheads. The horizontally shaded sections just above the mooring eye are water ballast compartments that fill through the holes shown: this use of water ballast was discontinued by 1887.

The top right buoy has the mooring eye recessed into the bottom plating. Buoys of this design were called Herbert buoys and were considered to have good riding characteristics.

At this time very large *'monster'* buoys were reported to be used at important dangers such as the Goodwin Sands. These were 6 metres high conical buoys with can, conical or spherical topmarks.

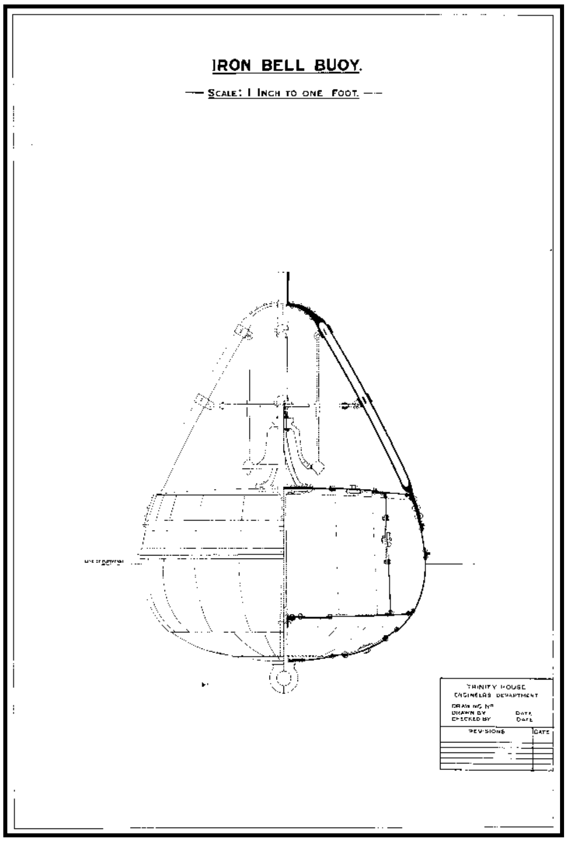



*Fig.27* Trinity House bell buoy

The hemispherical hull (Figure 27) of the Trinity House bell buoy would provide a rolling motion of the buoy to maximise bell action. The arrangement of internal bulkheads is shown as is the complex plating and mooring attachment at the base of the buoy.

There had been a visit to Trinity House by the US service in 1845. It was particularly noted that standard shapes and colours were used for buoys throughout the UK, apparently this was not the case in the US. The Trinity House buoys remained on station usually for six months. They were moored to stone sinkers with chain moorings and redundant lightvessel chain was often used. We can surmise that lightvessels were then usually moored with chain.

There was a French Lighthouse Service visit to Trinity House in 1855 to inspect developments in iron buoys and this resulted in the French Service developing a standard iron service buoy and a bell buoy.

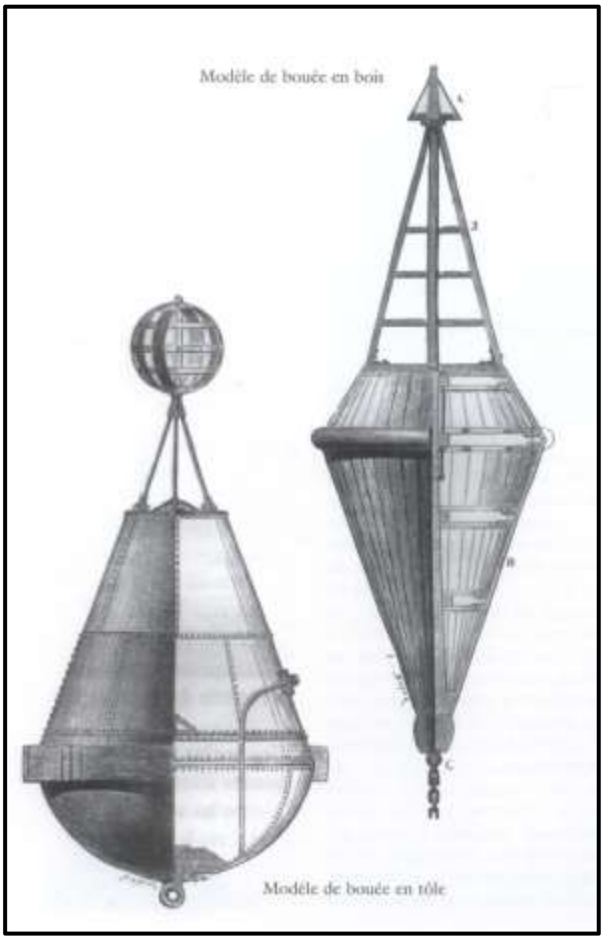



*Fig.28 French* iron buoy on left, wooden buoy on right

*Fig.29* French bell buoys

Wooden buoys continued to be used for many years. The US Department of Transport reported that a project to replace wooden buoys was underway in 1922. A Trinity House drawing of 1926 shows a mixture of types of small wooden and iron temporary marking buoys still in use.

Simple spar buoys made from the trunks of trees were widely used in areas with little tide range. The spar is being held upright by the tension of the mooring connection to the sinker.

In the US Mr Courtney (an English émigré) developed the automatic whistle buoy in 1876. The vertical motion of the buoy in the water (Figure 30) drives air through a central tube to operate a whistle. This principle was rapidly developed by other buoy manufacturers and is still in worldwide use.

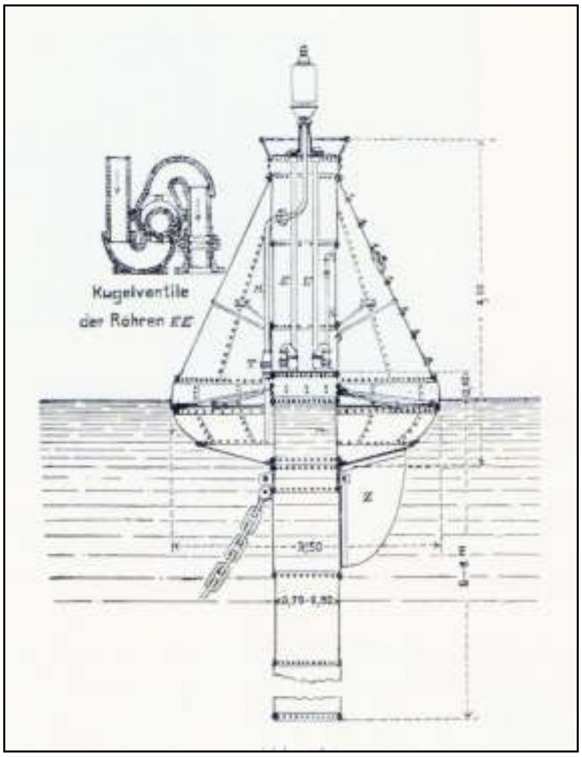



*Fig.30* Courtney whistle buoy

Trinity House invitations to tender for the manufacture of un-lighted buoys are reported in *The Engineer* ' in 1882 and 1887. (The 1882 design, Figure 31, was part of a larger drawing). This is for a 3.05 metre diameter buoy that is water ballasted. Considerable detail is provided for the iron work and the completed buoy is tested to 1.38 bar water pressure and the internal bulkheads to 0.69 bar.

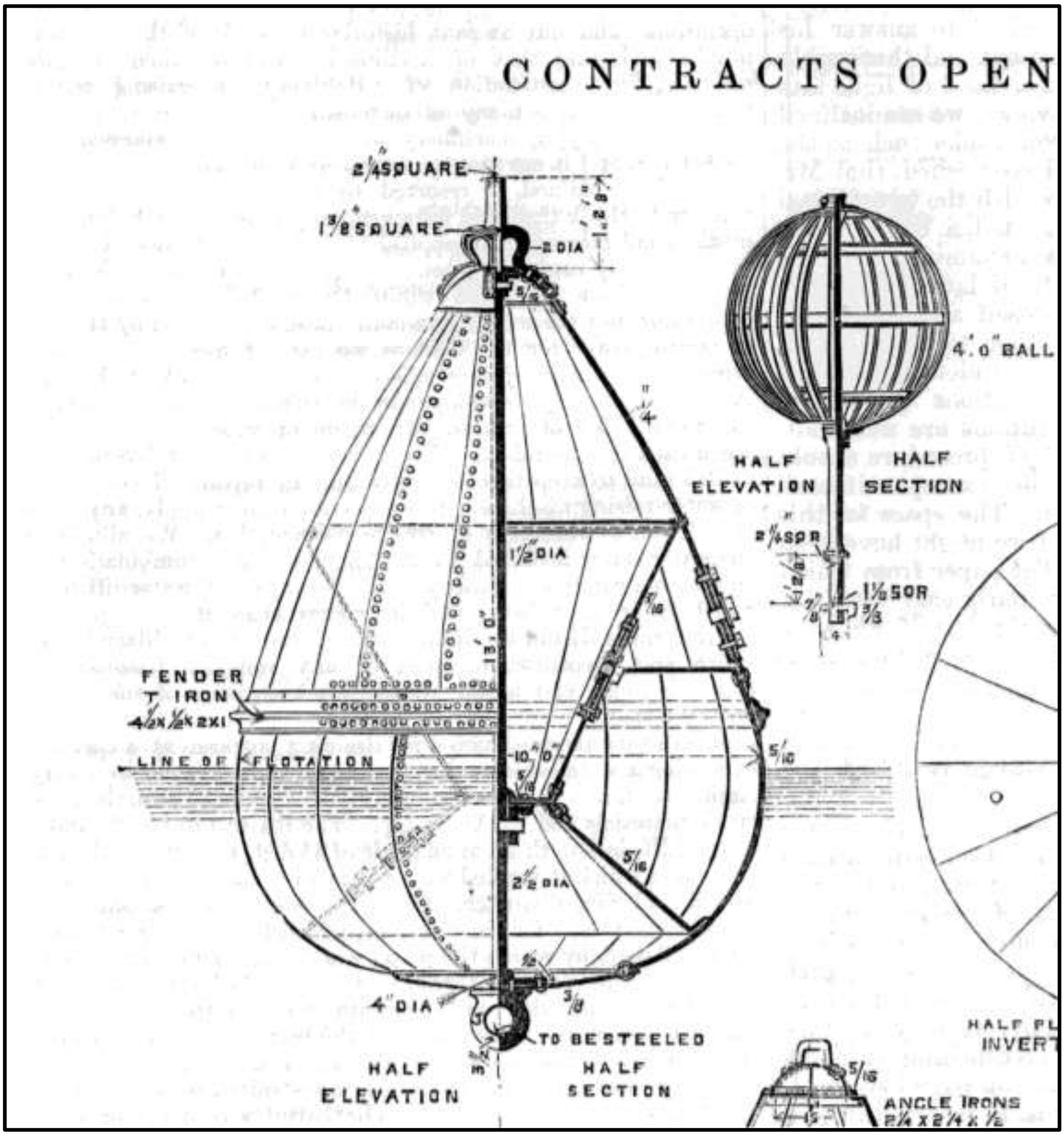



*Fig.31*

The 1887 design (Figure 32) shows similar sized buoys but with the mooring eye recessed into the base of the buoy. These were called Herbert buoys. There were no water ballast compartments and the buoys had a single, horizontal internal bulkhead.  The testing pressure has been reduced to 0.35 bar water pressure.

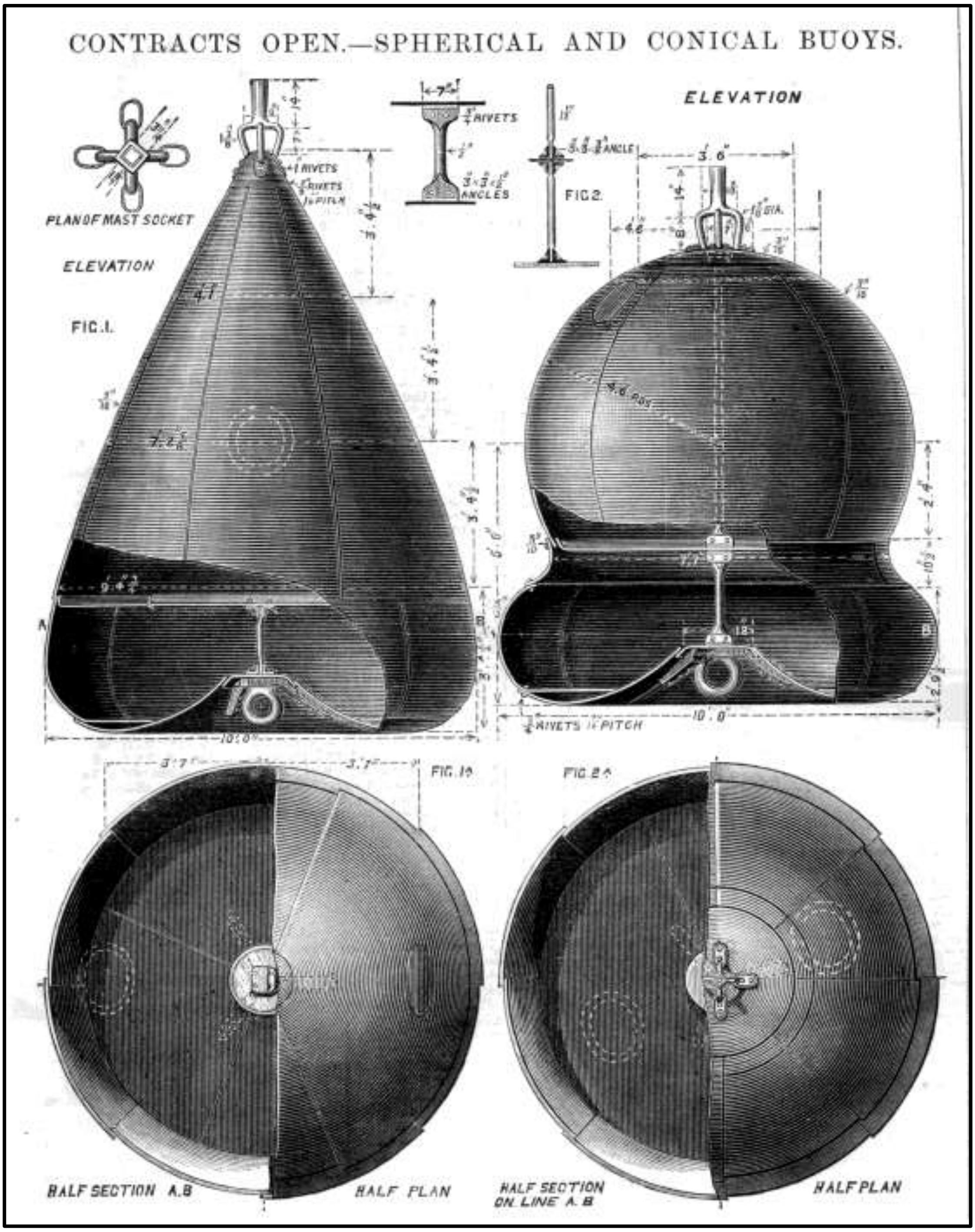



*Fig.32*

*Fig.33* French riveted iron buoy, 1880s design.

*Fig.34* The following illustration is from a Swedish listing of buoys from 1890 and shows the main navigation buoys along the south coast of England.

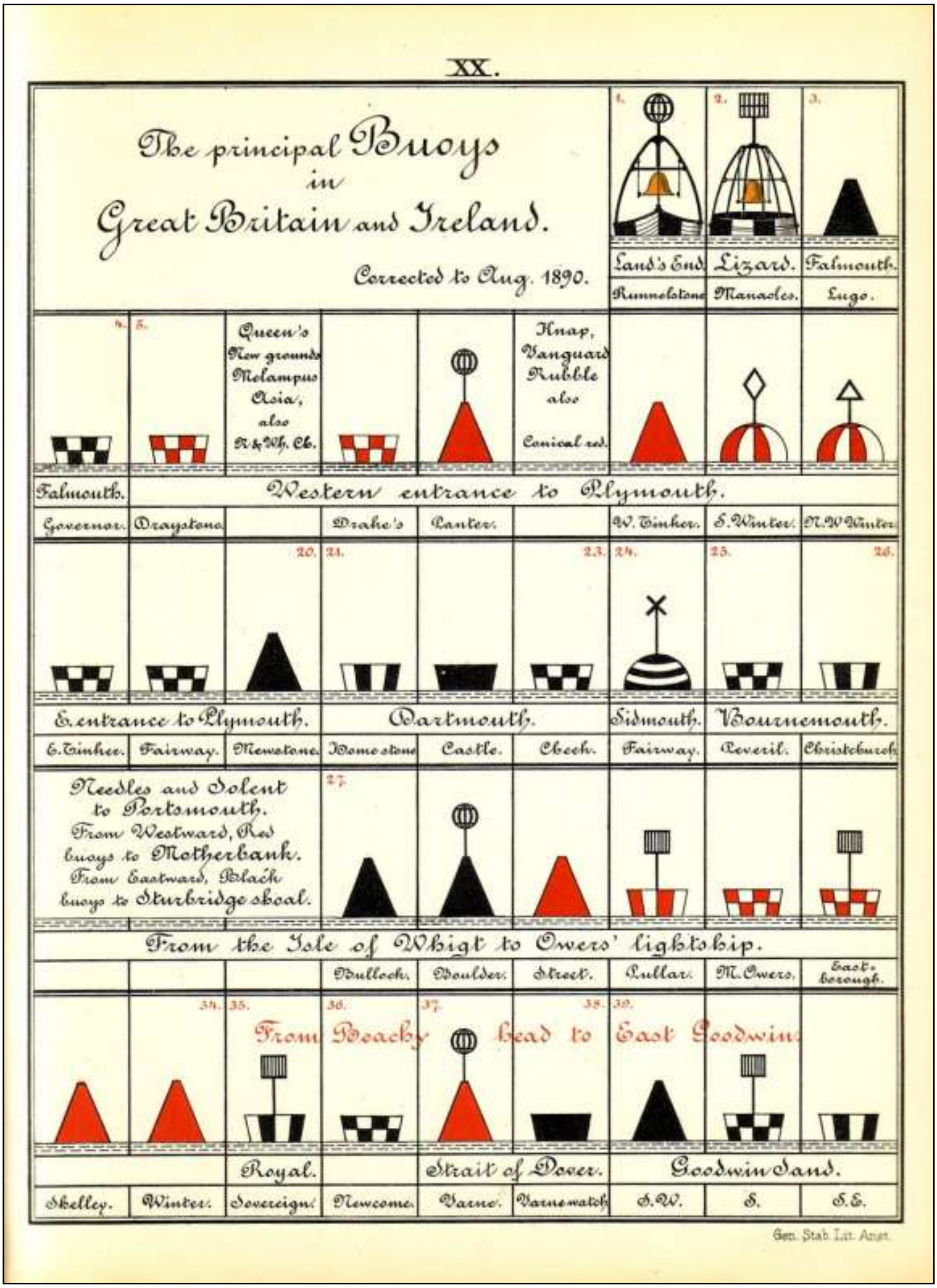
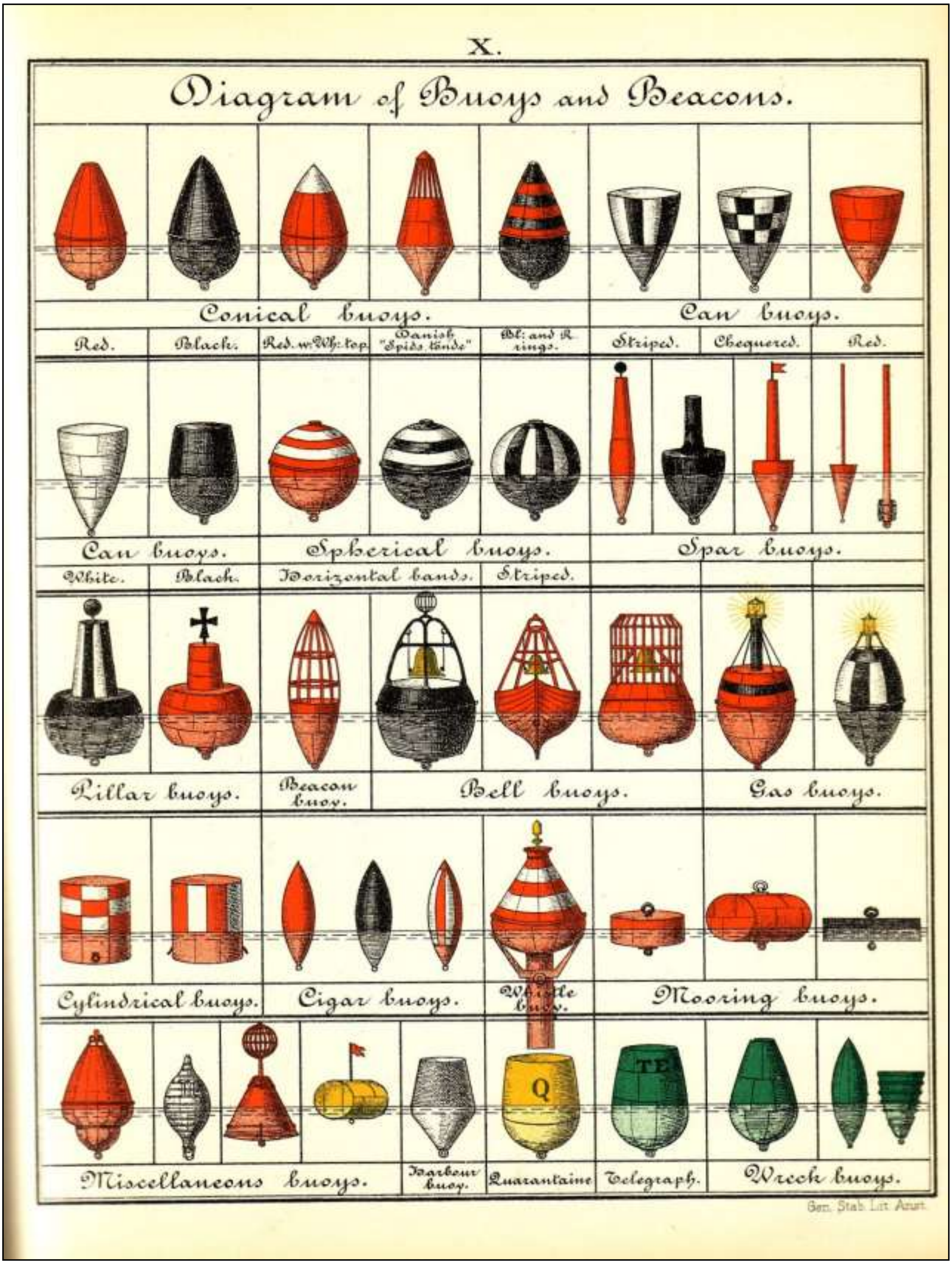


*Fig.35* This illustration shows the main buoy types in use around Europe in 1890. Note that gas lighted buoys have just arrived.



The design of iron and then steel buoys soon settled, in the early 1900s, into skirt and tailtube types for lighted buoys and can, conical and spherical shaped unlighted buoys.

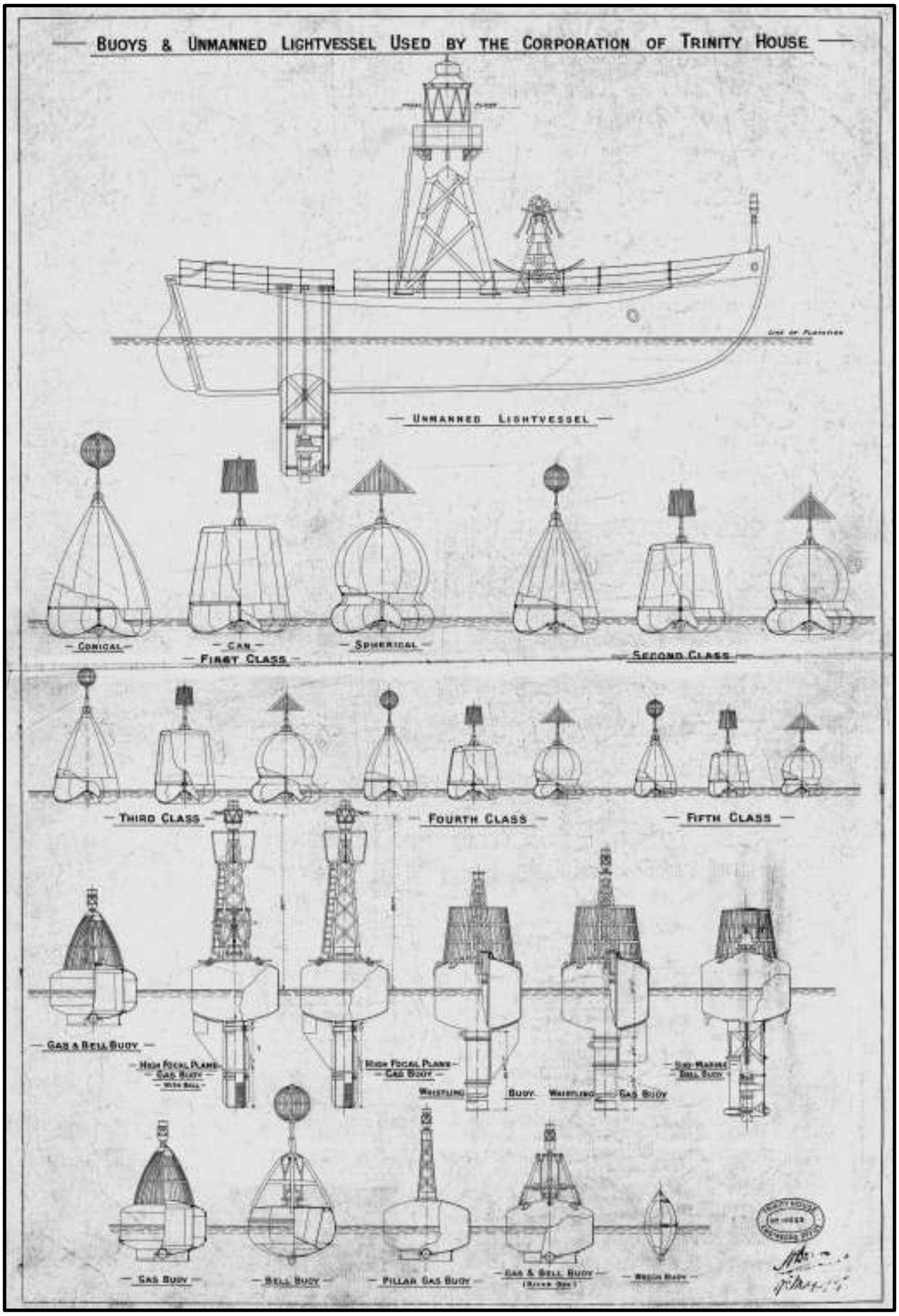



*Fig.36* Iron buoys developed by Trinity House, London, early 1900s

In Figure 36 the lighted buoys are oil gas buoys. The unmanned lightvessel (lightfloat) would have similar light, bell and underwater bell to those used on the buoys. The unlighted shaped buoys required very complex platework to achieve their finished shape. The cylindrical bodies of skirt and tailtube buoys were simply rolled from plate and the dished ends made from pre formed ends of the type developed for storage tanks and pressure vessels. Some Authorities used shallow conical ends and there are a few examples of flat ends being used. Construction changed from riveted to welded, in the 1940s, depending on the local ship building practices.

Mooring attachments vary considerably in detail around the world. Wooden buoys and the early iron buoys had a single mooring eye at the point of the conical body. The iron 'round bottom' and 'Herbert' buoys stayed with the single mooring eye but as lighted buoys were introduced at the end of the 1800s the idea of two mooring eyes, with the associated bridle mooring, seems to have arrived. Some Authorities have always favoured a single mooring eye and this has required the mooring point, for this type of buoy, to be placed to one side of the tail tube.

The time that steel buoys could be left on station very much depended on the life of the paint finish in order that the buoy provided an effective daymark. In the 1860s paint on iron buoys failed within the six months on-station period, causing all the buoys to appear red with rust. Paint systems steadily improved in the mid 1900s and made a significant step forward in the 1980s as epoxy marine paint systems were developed. These required significant investment in systems to prepare steelwork for painting but resulted in paint systems that will now last in excess of five years at sea.

Steel buoys have proved to be extremely robust and long lived. There are instances of well-maintained buoys lasting over 100 years.

## Plastic buoys

Many types of plastic have been used to construct buoys. The ability to easily form plastics into complex shapes, the inherent weather resistance of many plastics and their ability to be manufactured in an appropriate signal colour have resulted in the production of many types of plastic buoys.

Plastic buoys were discussed at the lighthouse authorities' conference in 1955. Glass reinforced plastic (GRP) was thought to be an almost maintenance free material that could be manufactured with permanently coloured resins and could be formed into complex shapes in relatively low cost moulds. There were even claims that marine fouling would not adhere to GRP. Commercially manufactured GRP buoys became available in the 1960s and 1970s. These tended to be copies of existing steel buoys and their design often did not take advantage of the structural possibilities of the GRP.

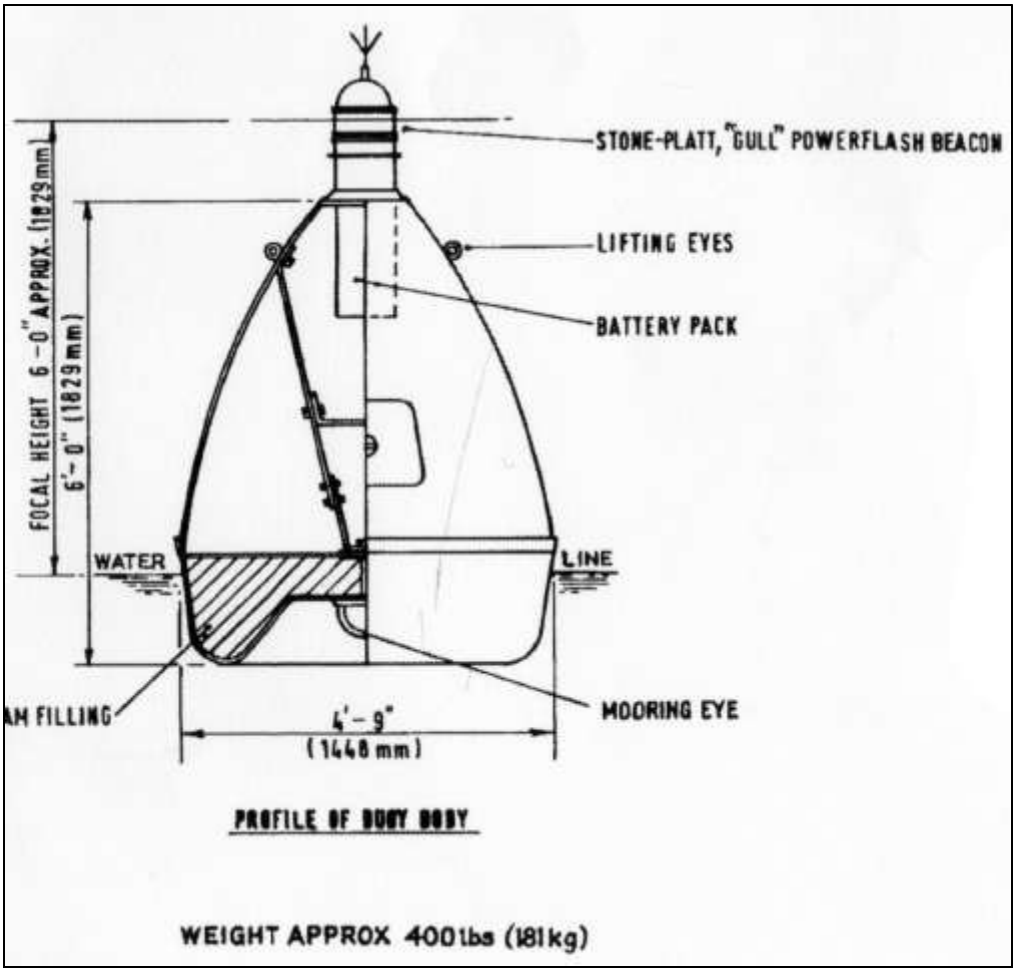



*Fig.37* Small GRP
buoy with electric light

Large GRP buoys highlighted the brittle nature of the material. They were easily damaged when being handled and could suffer serious damage in quite minor collisions. The attachment of mooring and lifting eyes and other highly stressed fittings proved difficult and the long term colour stability of the available resins proved to be very poor. There was little success with large GRP buoys but smaller buoys for harbour and river marking were successful and were cheaper than similar steel buoys

Foam plastic buoys utilise closed cell foam. This is a type of foam where all the individual bubbles within the foam are entirely separate. The foam is buoyant and does not absorb water in the way that a sponge does. Various flexible plastics have been used for the structure of the foam. The buoy body and sometimes the superstructure, are made from layers of the foam material. Some buoys then have a substantial layer of a flexible plastic 'skin' applied to the outside of the foam. A central steel core connects the mooring and lifting eyes. These buoys have achieved some success but never achieved dominance in the market place, possibly due to the high cost of suitable foam materials.

The rotomoulding process was originally developed for the manufacture of robust polyethylene containers. By this process complex hollow shapes can be produced in sheet metal moulds. The early moulding materials suffered problems such as brittleness at low temperatures and poor colour stability. Trials with rotomoulded daymarks on three metre gas buoys in the early1980s were abandoned when a number of these daymarks shattered during cold winter weather. The moulding process and the plastics have progressed and rotomoulded polyethylene buoys now make up a large proportion of buoys manufactured worldwide. Some small buoys are entirely moulded, including the mooring attachment. Medium and large buoys usually have a steel core structure carrying the mooring eyes, ballast and superstructure attachment.

*Fig.38* Small rotomoulded buoy with rotomoulded superstructure

*Fig.39* Large rotomoulded buoys
with steel core structure and
aluminium superstructure.
(Note concrete sinker)

# 5. LIGHTED BUOYS

The 19th century had seen many developments in artificial lighting using vegetable and mineral oils, gas and electricity but the problems associated with operating any system on a buoy, constantly moving around at sea were considerable.

The usual lighting oil in the 18th century had been whale oil. In 1784 Argand had developed a lamp with a tubular wick within a glass chimney that burned with an almost white light. Whale oil was replaced with Colza oil (rape seed oil) in the late 1700s. Paraffin (kerosene in US) was not in use until 1850. This was a brighter burning oil but it required more air to burn efficiently and suitable burners were developed by the 1870s.

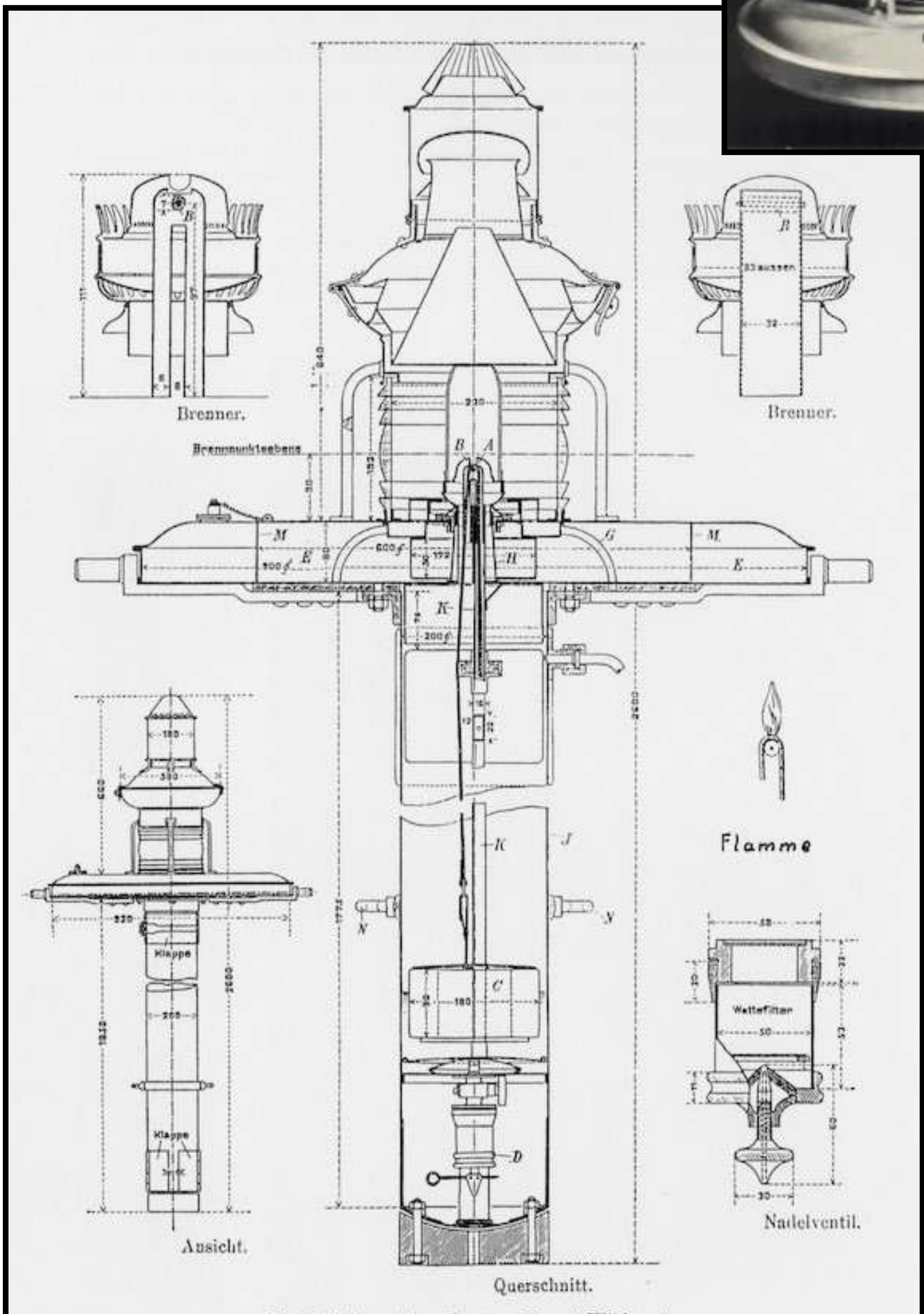
By the late 1800s lightvessels had developed into substantial vessels providing large daymarks. The lanterns were usually lowered down to deck level during the day and hoisted up the mast at night, (see Figure 18 Nore lightvessel 1830). Lighting was provided by oil fuelled Argand lamps with reflectors that were positioned around the vessel's mast and in some cases individually gimballed.

**Oil burning lanterns**

Some sophisticated self-contained oil burning lanterns were developed for use on buoys by Wigham in Ireland and Bourdellsche in France. These had Fresnel lenses and sophisticated ventilation systems to prevent the flame being extinguished by wind or movement of the lantern. G.V. Lyth in Sweden developed a paraffin lantern specifically for use on buoys in 1890.

This drawing and photograph (Figure 40) show the Wigham lantern that had a mechanism to constantly move the wick so that the area of the wick at which the oil was burnt was continually renewed. References suggest that these lanterns would burn for 10 days without attention. The lantern burnt continuously and provided a fixed white light that in practice was probably orange in colour.

*Fig.40* Wigham lantern




Die Petroleum-Dauerlampe „Bauart Wigham“.

The Wigham lanterns were primarily used on beacons but also on some buoys.

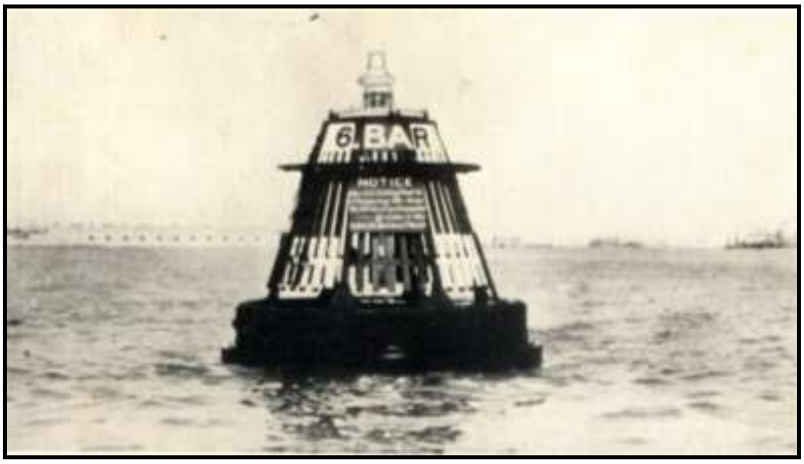



Fig.41 A Wigham lantern on a buoy in Portsmouth harbour (UK) date unknown.

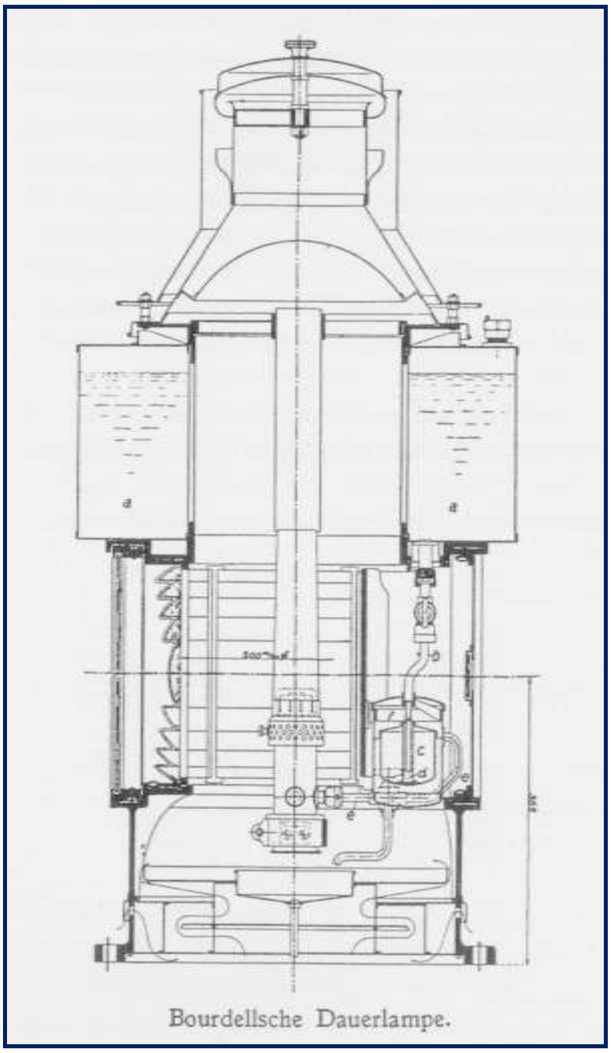



*Fig.42* A Bourdellsche lantern

These lanterns do not seem to have been used extensively on buoys and would probably only have worked at very sheltered buoy stations and would need servicing very regularly (seven or ten days). Some were still in use in 1911.

**Open flame gas lanterns**

The first major buoy lighting success was by a German, Julius Pintsch. He had developed a gas lighting system for passenger railway carriages. A stable gas, referred to as 'oil gas' was distilled from a variety of mineral compounds and compressed into steel gas holders. The gas was burned in an open flame burner that would have produced a yellow flame. 52,000 railway carriage lighting units had been produced by 1893 and had been marketed around the world.

Following a chance meeting with a Russian official, Julius Pintsch designed a lighted buoy that had the 'oil gas’ stored in the buoy body at a pressure of six atmospheres. The first of these lighted buoys was produced in 1876 and by 1877 were in use on the waterways leading to St Petersburg, for which Mr Pintsch received the award of the Order of Stanislaus from the Tsar. A German patent for gas lighted buoys was granted to Pintsch in 1877. By 1880 Pintsch buoys were in use in England in the Thames estuary and were trialled by the US service in 1884 in New York and adopted for service use in 1884.

The Pintsch system was licensed to a French company, SIEGH (International Society of Gas Light Oil).

*Fig.43* An early Pintsch buoy

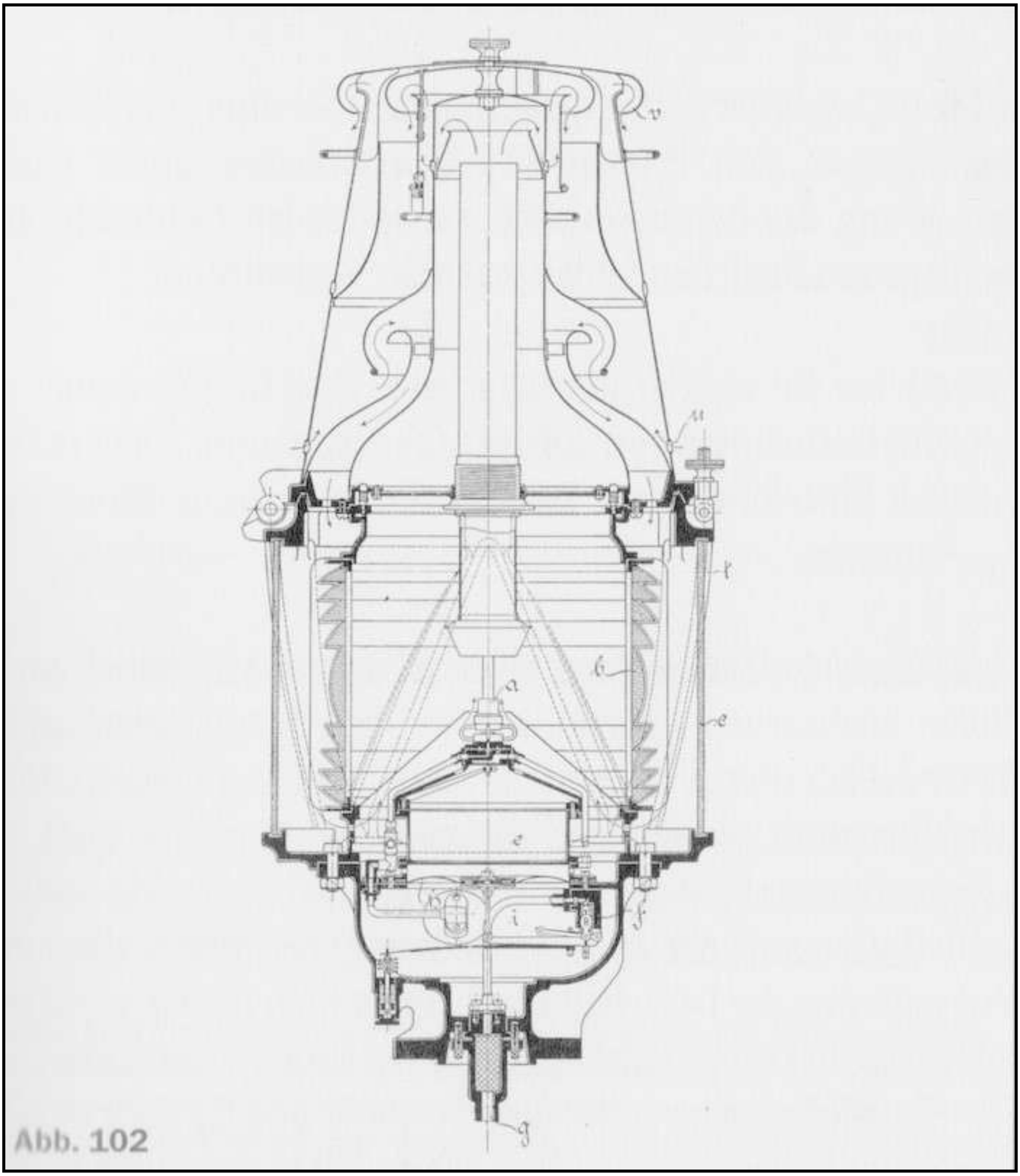



*Fig.44* Pintsch open flame lantern

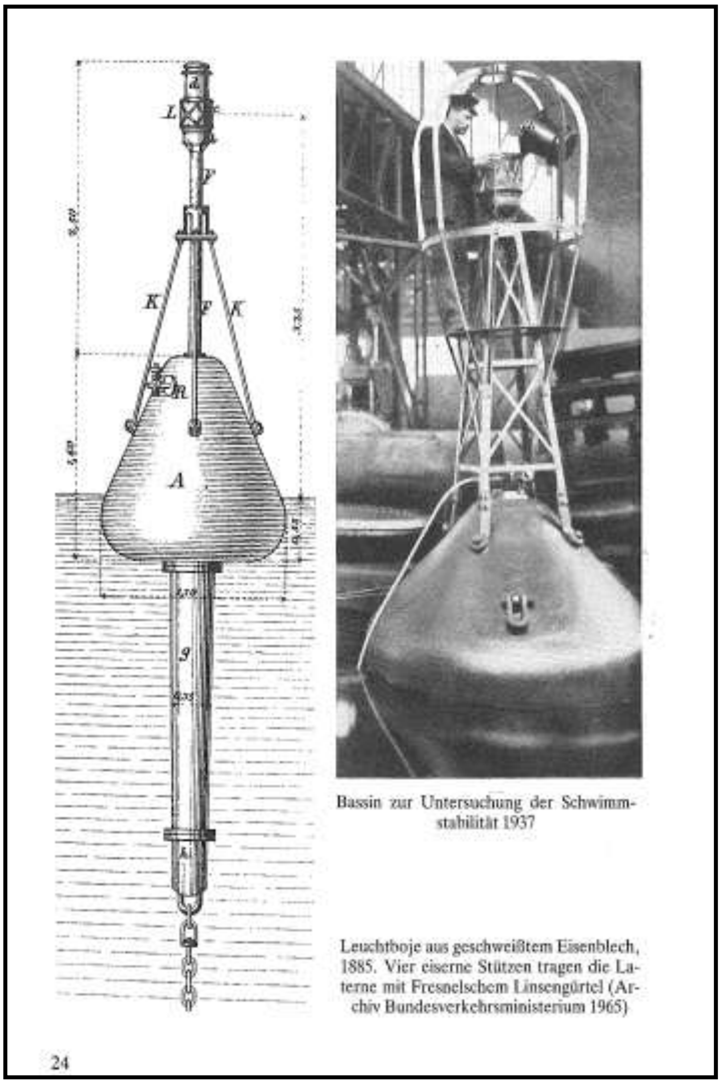
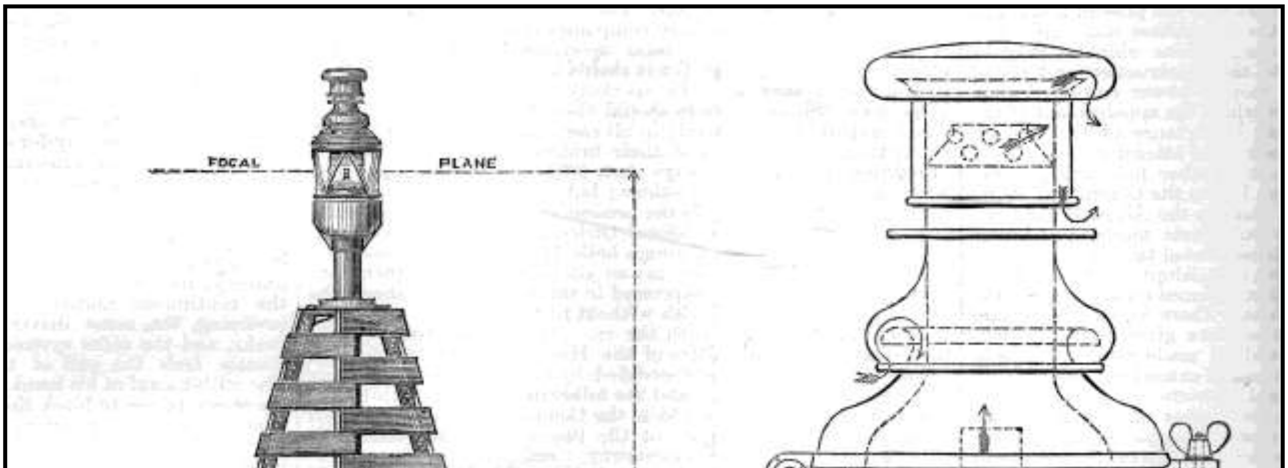



*Fig.45* A Pintsch buoy from 1885 and the photograph shows a later buoy in a test tank.

The Pintsch Engineering Co. utilised spherical steel buoy bodies developed from mine bodies they had produced in the Franco Prussian War (Pintsch Archive). They incorporated these into a high focal plane tail tube buoy. The early buoy bodies were constructed from steel plate with hammer welded seams. Later buoys used more conventional riveted construction.

There is a report of early trials of Pintsch buoys by Trinity House in *'The Engineer'*, 25th April 1879. Buoys were trialled on the Thames, one close to the Trinity House Blackwall depot and another near to the exposed Mouse lightvessel station in the Thames estuary. The Blackwall buoy was of 1.7m³. gas capacity contained at a pressure of 6.2 bar. This was found to operate a continuously burning light for 27 days and the light could not be extinguished '*by forcing water at it*'.

*Fig.46* shows the Pintsch lantern and the design of buoys subsequently built for Trinity House, following the successful trials. These were designed for four months operation.




PINTSCH'S GAS ILLUMINATED BUOYS.—(*For description see page 209.*)

The lantern contained a regulator that reduced the gas pressure to 0.00125 bar. This then fed gas directly to the burner. This regulator used a spring to control the gas pressure; the previous regulators used for railway carriage lighting had used dead-weight regulators.

The lantern had a Fresnel lens and a sophisticated ventilation system. It provides the basis for the design of subsequent oil gas and acetylene lanterns. The report notes that the first trial buoys had *'an ordinary square framed lamp'*, but unfortunately provides no more details.

A valve was incorporated on the deck of the buoy to allow the buoy to be re-fuelled with gas from a tender.

The trial report also notes that Pintsch had developed an electrical system to extinguish the light at sunrise and re-light it at sunset. Trinity House seems to have chosen to avoid this added complexity.

*Fig.47 A* Pintsch gas buoy in the River Thames in 1882

These Pintsch buoys were soon in use around the world supported by the network of gas distillation plants that Pintsch had established for their railway lighting equipment. The original buoys had a continuously burning light that could operate for thirty days. A clockwork occulting mechanism was introduced in 1881, reducing gas consumption and gave a three month service life. Further development resulted in a flasher mechanism powered by the gas flowing to the burner, patented in 1883. The open flame burner in a 200 millimetre lantern provided a light intensity in the order of 30 - 40 candelas.

Some large French buoys had operating periods of four months. By the 1890s some French light vessels were being replaced by large oil gas buoys.

## Incandescent mantles

In the early 1800s Auer von Welsbach had developed the incandescent mantle. He later worked with Pintsch to develop a mantle that was sufficiently robust for use in buoy lanterns. This would greatly increase the light intensity as well as providing a white light. A patent was granted in 1885 and Pintsch marketed 200 millimetre lanterns with a (white) intensity of 400candelas. Pintsch also provided kits of parts to convert older open flame lanterns to incandescent mantle lanterns.

The Lighthouse Authorities conference in 1905 reported 1317 lighted buoys in use worldwide.

*Encyclopaedia Britannica* in 1911 noted that gas operated occulting mechanisms were in use, as were incandescent mantles which produced a brighter white light when compared with the original open flame burners. There were then around 2000 lighted buoys world wide and very tall tail tube buoys were in use in France, several 7.8 metre focal plane height buoys and one 10.3 metre on the Gironde. The French service had, in 1912, six gas production plants, 133 lighted buoys and three automatic lightfloats.

*Fig.48* An illustration of a Pintsch oil gas lantern with flasher and the small rigid type of mantle that had been developed by Pintsch.

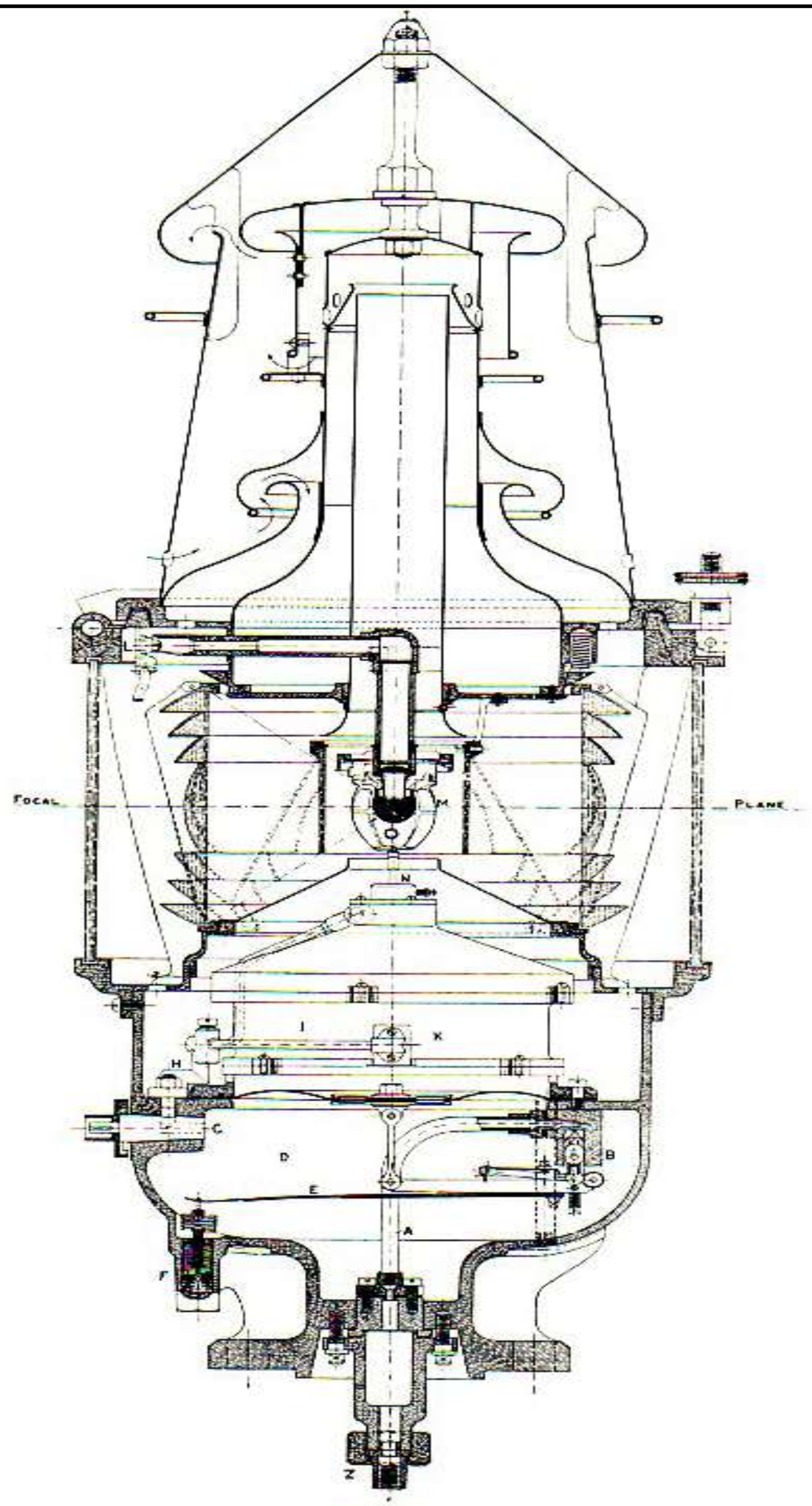



Plate 1.

**No. 2032.**

Combined Mantle Carrier and Protector.

Note.—Mantle No. 2028 is not included and should be ordered separately.

**No. 2036.**

No. 1 Porcelain Nozzle for 300 m/m incandescent lanterns (marked 24).

**No. 2037.**

No. 3 Porcelain Nozzle for 200 m/m incandescent lanterns (marked 16).

**No. 2038a.**

Nipple for 300 m/m incandescent lanterns.

**No. 2038c.**

Ditto for 200 m/m lanterns.

*Fig.49*

Services around the world produced their own 'oil gas' under licence from Pintsch. These included the UK, France, Germany, Holland and the USA .The process was based on high temperature distillation from crude oil or oil bearing shale in iron retorts heated in coal fired furnaces.

There are details and drawings of Trinity House oil gas plant in 1911 attached as an appendix.

## Early electric lighting

In 1888 (US Department of Transport report) six electrically lighted buoys were installed in New York harbour marking Gedney's Channel and switched on November 7th. These were solid wood spar buoys, 13.7 metres long carrying *Swan* carbon filament lamps. This was only a few years after the filament lamp had been invented and one of the first installations of underwater power cables. Red coloured filters were installed in 1889 to identify buoys on one side of the channel. The lamps burned continuously when the power was switched on. The US authorities were aware of the use of oil gas buoys in Europe but considered that electric filament lamps would be more reliable than gas lights and that spar buoys would be more secure on

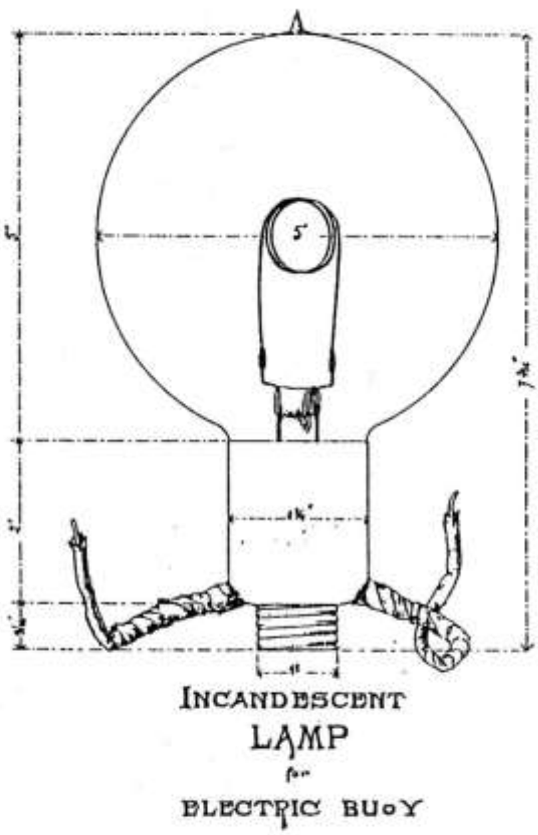



*Fig.49* Gedney Channel carbon filament lamp 1891

the exposed stations subject to ice in the winter than conventional buoys. The spars were directly shackled to the sinkers to prevent rotation of the power cable. This would now be called an articulated beacon. Initially a 100V DC supply was used. This was generated at a shore station with two steam engines driving dynamos. The voltage loss in over six miles of underwater cable that delivered the electrical power to the buoys must have caused serious problems. The white lights were found to have a range of five miles and the red two and a half miles. The system was changed to AC in 1895 and extended to eleven buoys. These new buoys were fifteen metres long. The power supply was 1000V transformed down to 100V on the buoy.

Thirteen electrically lighted buoys were installed at the Chicago fair in 1893. This was a temporary installation with over thirteen miles of supply cabling. Initial trials of an AC system were unsuccessful and the system operated on the same 100V DC supply system as the Gedney Channel.

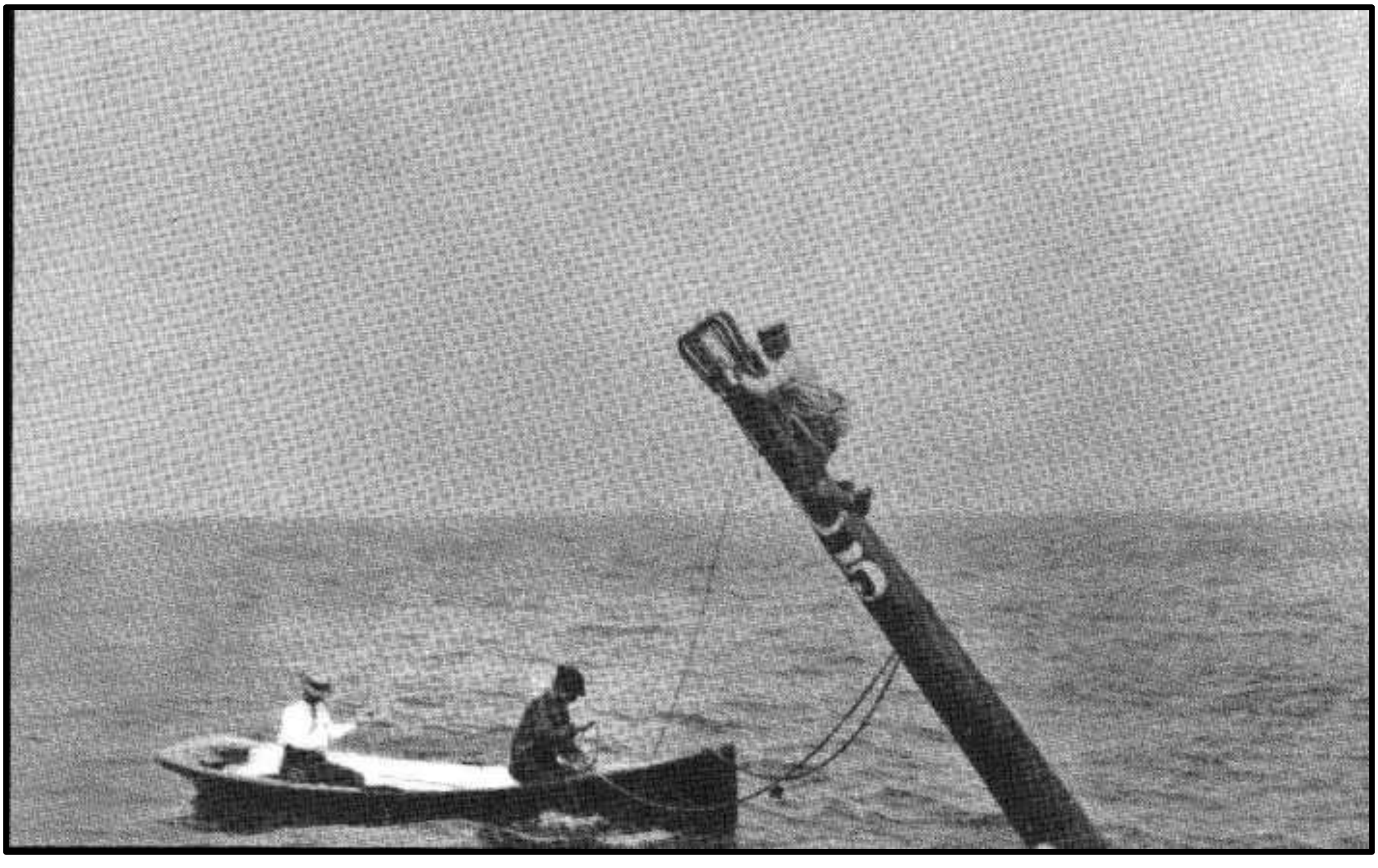



*Fig.50* Servicing underway on one of the Gedney Channel, New York harbour buoys

Although the lighted channel was considered a great success as vessels were able to transit safely at night, there were many outages. Ships fouled the cable with anchors, ran aground on it, cut it with propellers and lamps failed due to collisions and buoy motion. At times light failures averaged one per week per buoy. However their unreliability had been anticipated as shown by the following optimistic Notice to Mariners.

**NOTICE TO MARINERS.**
**(No. 304 of the year 1888.)**
**UNITED STATES—NEW YORK.**
**NEW YORK APPROACH.**
***Light-Buoys in Gedney Channel.***

THE United States Government has given notice, that as soon as practicable, probably about the end of September, 1888, an attempt would be made to light Gedney Channel, approach to New York from the southward, by six 100-candle power incandescent electric lamps, inclosed in lanterns supported by spar buoys :—

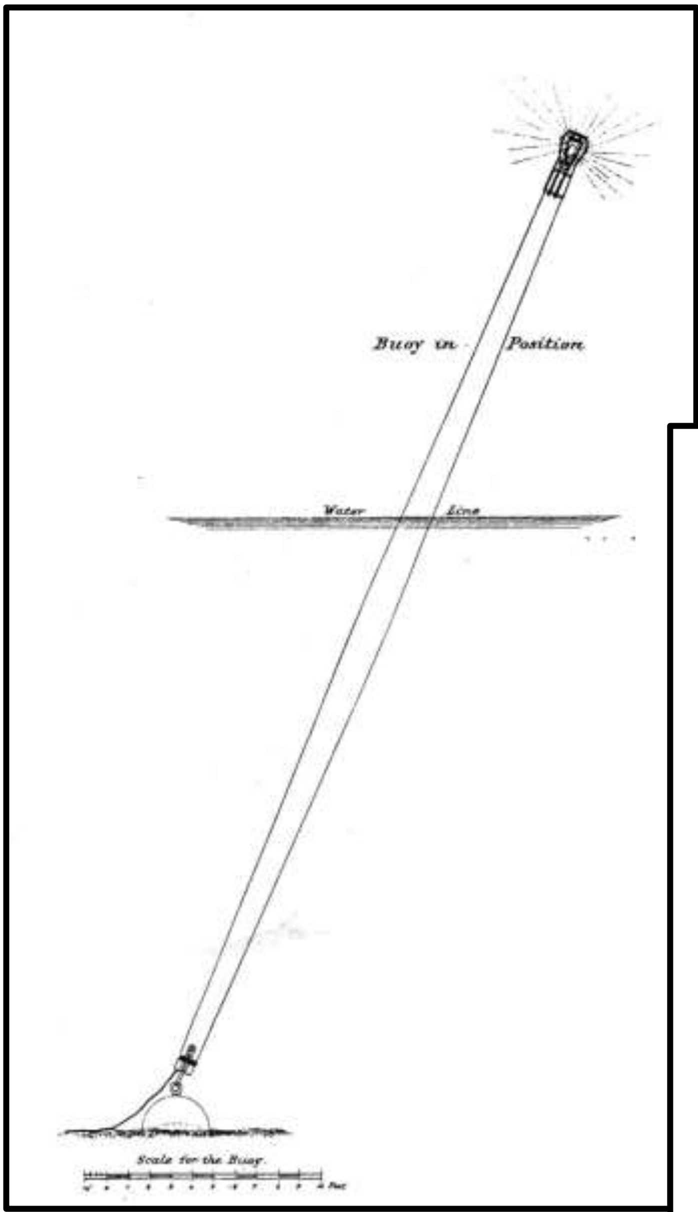
The buoys are placed seaward of, and close to, the can and nun buoys which mark the channel, and are coloured, lettered, and numbered like those buoys. The lights of buoys, G. 1, G. 4, and G. 5 are red, and those of buoys G. 2, G. 3, and G. 6, are white.

Owing to the uncertainty of incandescent lamps, some of the lights may at times be extinguished, but it is thought that any three of them will furnish a sufficient guide through the channel, and that the arrangement of colours is such that, if any three are lighted, it will be easy to determine which they are.

By command of their Lordships,
*W. J. L. Wharton*, Hydrographer.
Hydrographic Office, Admiralty, London,
27th September, 1888.

This Notice affects the following Admiralty Chart :—Approaches to New York, No. 2491. Also, Sailing Directions for the principal Ports of the United States, 1882, pages 132, 133.

*Fig. 51* Notice to Mariners, The London Gazette October 5th 1888



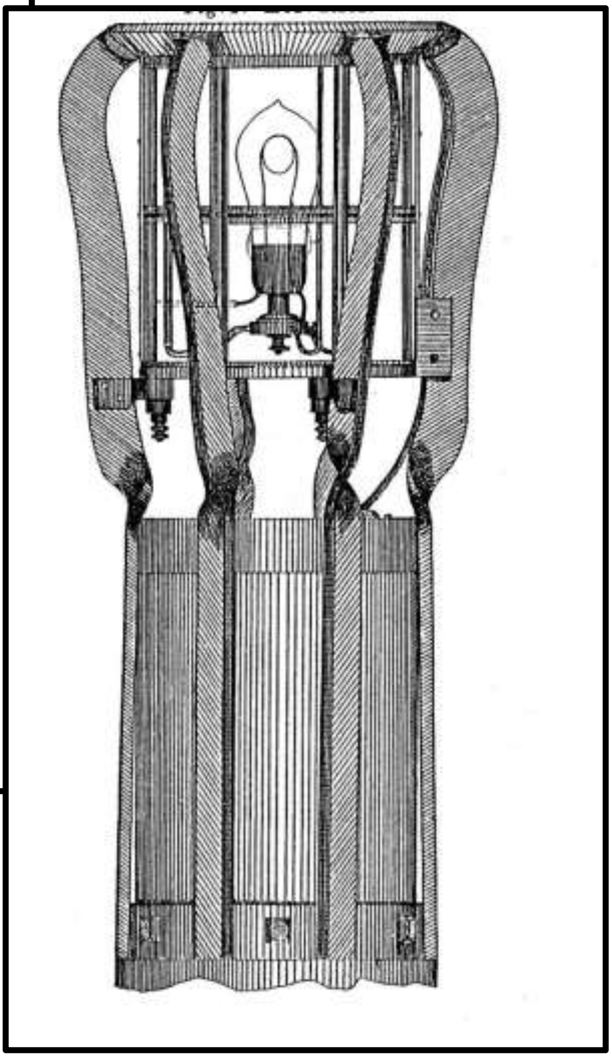



*Fig. 52*
Gedney's Channel spar buoy and lantern

The Gedney Channel installation had demonstrated the considerable advantages that would be provided by lighted buoys. As the reliability of gas buoys became accepted the electric spar buoys were removed in 1905 and replaced with steel gas buoys.

A system similar to the Gedney Channel was trialled on the River Jade in Germany from 1893 to 1896. This used a 500V AC underwater supply cable with power generated at the Wangerooge lighthouse. A transformer on each buoy supplied a lantern that had separate main and standby lamps. Wooden spar buoys with floats were used with the spar directly shackled to the sinker also to prevent rotation of the electrical supply cable (as reported at the Paris Congress of 1900). They were discontinued in 1901 to be replaced by more reliable gas buoys.

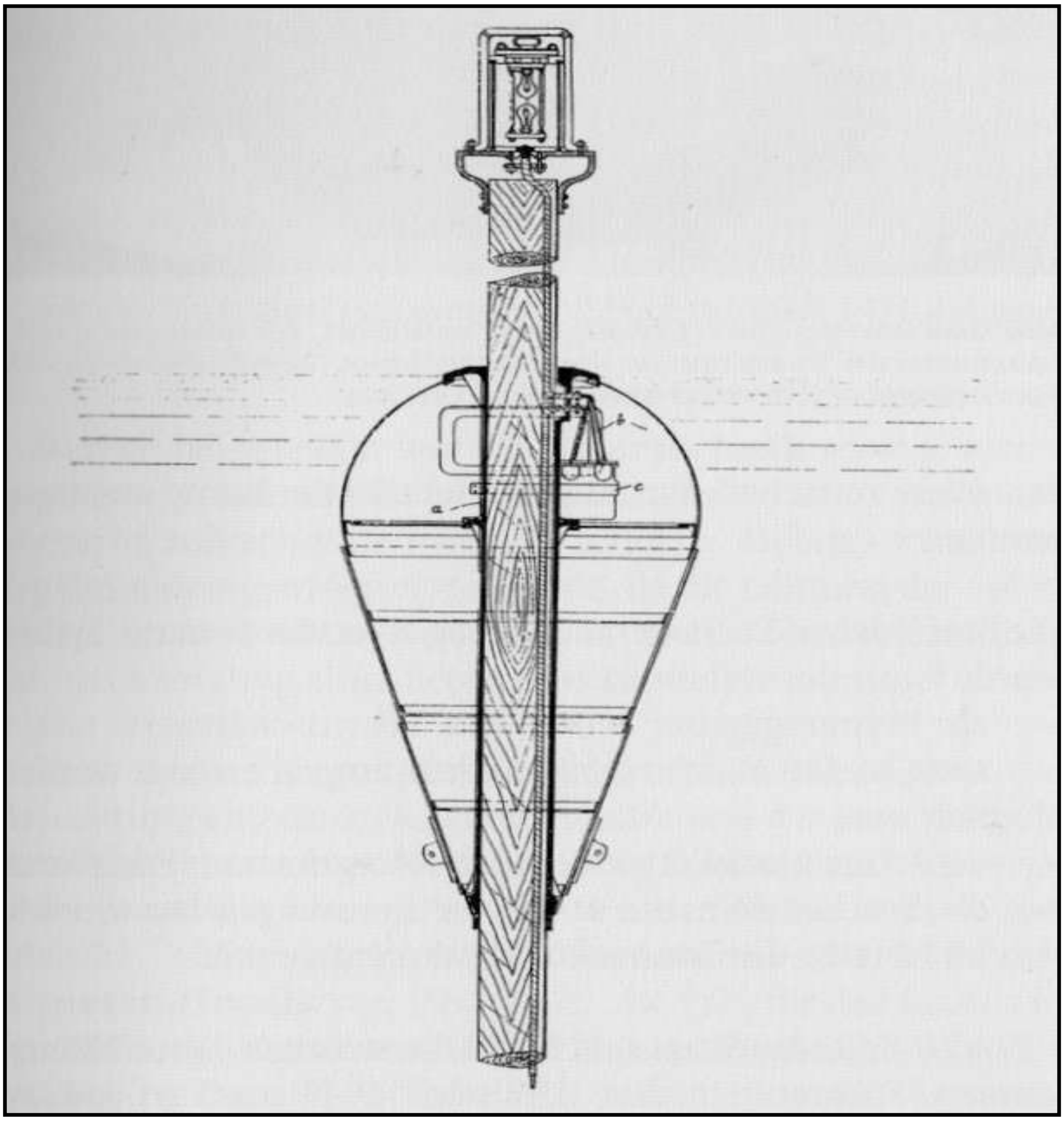


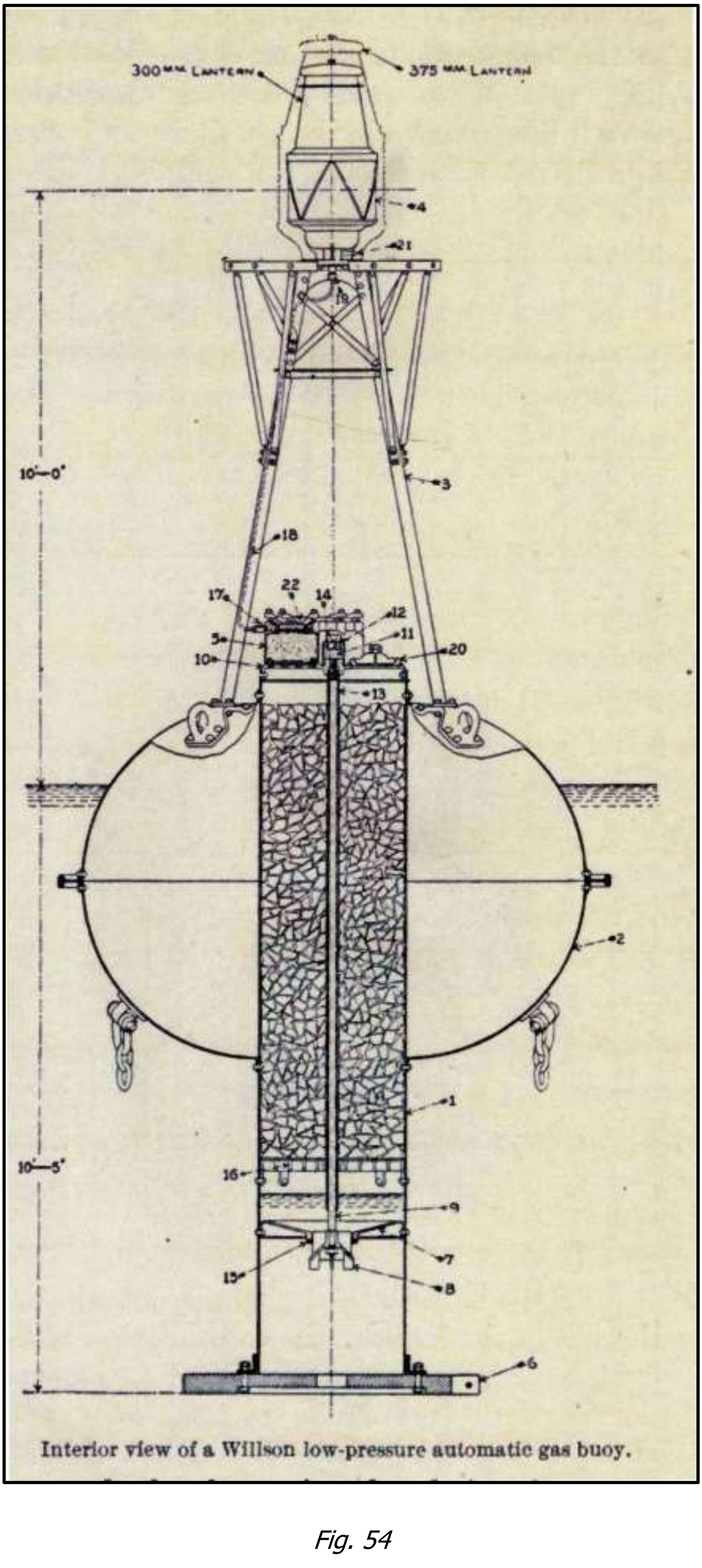

*Fig.53* River Jade buoy showing top of spar with float and twin lamps

A similar electric buoy was patented in England in 1903 (see Patent 26249 with drawing in Appendix) but there is no record of this buoy being used in service.

## Acetylene lighting

Acetylene gas was discovered in 1892. It has the particular advantage that with a correctly designed open flame burner it can burn in air to produce a white light. Burning equal quantities of gas the acetylene flame will provide a light of approximately seven times the intensity of an open flame oil gas light. Acetylene is capable of operating very fast flash times and hence gas consumption can be greatly reduced when compared with oil gas. However acetylene is extremely explosive and liable to detonation in widely varying ratios of acetylene to air and initially there was no practical means of safely storing acetylene.

The Canadian Service installed acetylene generating plants at depots and on-board tenders in the period 1901 to 1903. The acetylene was compressed into storage tanks on beacons and into the bodies of converted Pintsch buoys at pressures of 10 to 14 bar. There were several accidents; in 1905 three buoys exploded and the superstructure of a tender was destroyed while buoys were being filled with acetylene at a depot. The design of the Wilson buoy from 1900 attempted to overcome the acetylene storage problems by having an on-board acetylene production plant. The acetylene was generated by the reaction of calcium carbide and water within the buoy. A buoy working on similar principles was developed by Commander R. von Myhlenfels in Sweden in 1902. The Wilson buoys were introduced by some services, particularly US and Canada. There were still several disastrous explosions when the buoys were being serviced and other operational problems due to the water in the acetylene generator freezing in cold weather. The US service trialled the buoys from 1903 to 1906 but discontinued them due to their danger. The Canadian Service still had 250 in service in 1911.




Interior view of a Willson low-pressure automatic gas buoy.

*Fig. 54*

The operation of the Wilson Acetylene buoy (Fig. 54) is as follows:

The generator (1) is filled with carbide as shown, and the buoy is placed in the water with the valve (8) open and the valve cap (14) in place. Water enters the bottom of the generator tube through the hole shown in the centre of the counterweight (6) and then passes through the valve (8) up toward the grate (16) and finally reaches the carbide resting on the grate; this at once produces gas, which passes through the purifier (5), thence through the small valve (17) and pipe (18) to the lantern (4), to which the pipe is connected by the coupling (19). When gas is produced faster than it is burned in the lantern, it accumulates in the generator and presses the water downward away from the carbide, thus stopping the generation of gas (the illustration shows the generator in this condition). When the surplus gas is consumed the water reaches the carbide again and more gas is produced.

Major advances were made in the early 1900s by the AGA Company in Sweden and in particular by the engineer Gustav Dalen in the safe storage of acetylene. The acetylene gas was dissolved in acetone which was absorbed, under pressure, in a porous mass within a steel cylinder. Rather than attempting to store the gas in the buoy body the storage was within robust steel cylinders. Refuelling the buoy was then accomplished by exchanging full cylinders for the empty cylinders.

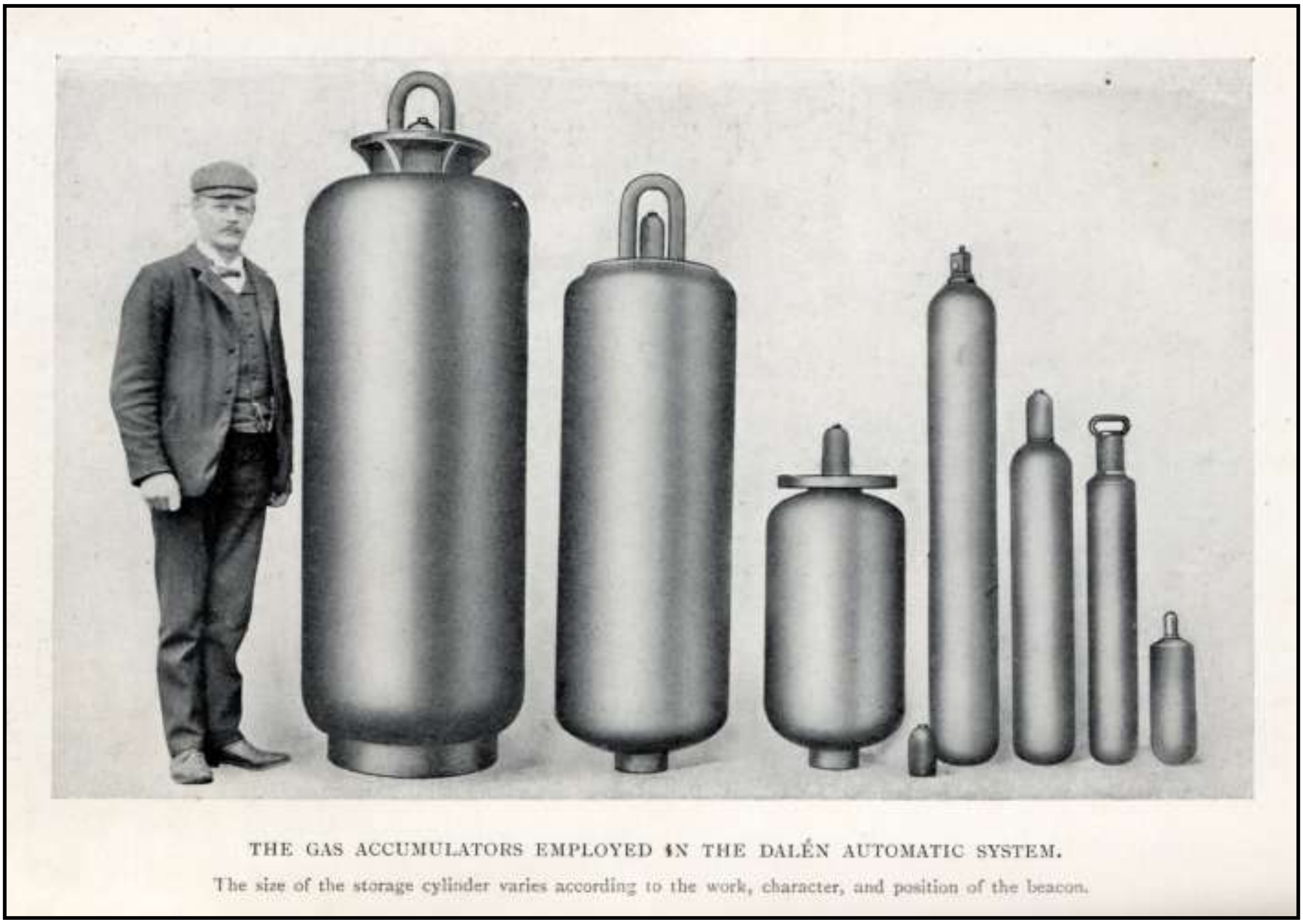



*Fig.55* AGA acetylene cylinders

Dalen also developed complex, but highly reliable gas flashers. The flasher mechanically reduced and regulated the pressure of the gas from the cylinder and fed pulses of gas to the burner (in the lantern) so that the required flashing light character could be produced. The pulses of gas were ignited by a continuously burning, very small pilot flame.

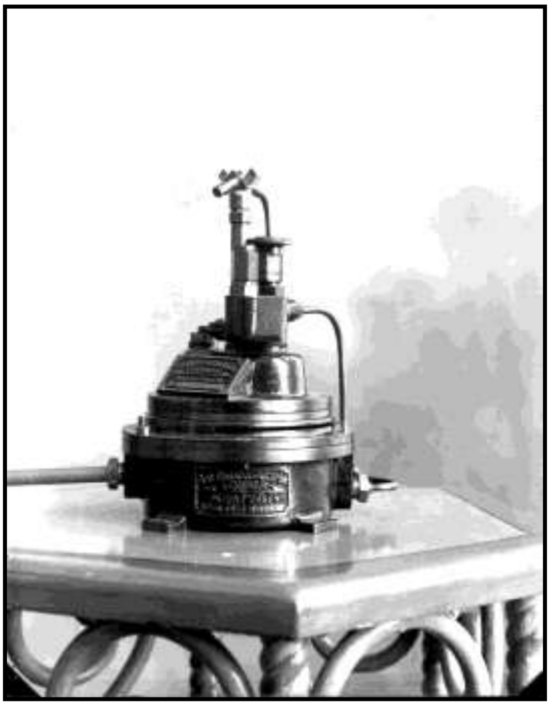


*Fig.56* Early AGA acetylene flasher 1910

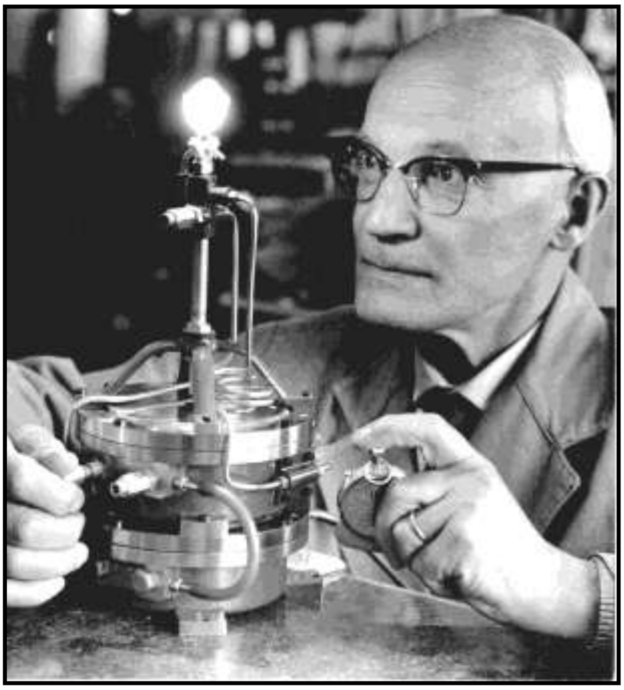


*Fig.57* AGA flasher on test

The acetylene gas is burnt in a Y shaped ceramic burner that directs two jets of gas towards each other and ensures that the correct volumes of gas and air are mixed in the combustion process. The basic flasher could provide a series of flashes of a timed length at timed intervals. Two stage flashers could then provide group flash characters. The pulse of gas from the flasher was delivered by the movement of a diaphragm made from oiled goat's skin. The flashers had to be run under test for several days prior to use to ensure that the diaphragm was flexing uniformly and the flasher had settled into a stable operating character. The AGA gas storage system and the AGA gas flashers provided the means to operate buoys and remote beacons, unattended usually for at least one year. These became the industry standard in many parts of the world and some are still in use today.

*Fig.58* Early AGA buoy built for Montevideo

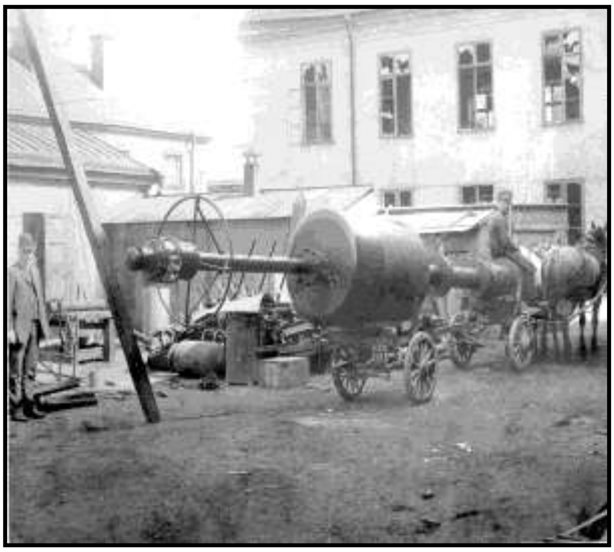


*Fig.59* AGA Tail tube buoy

*Fig.60* A small AGA buoy with a gas cylinder providing ballast at base of tailtube

*Fig.61* AGA promotional photographs from early 1900s

*Fig.62* Early AGA buoy with single central gas cylinder

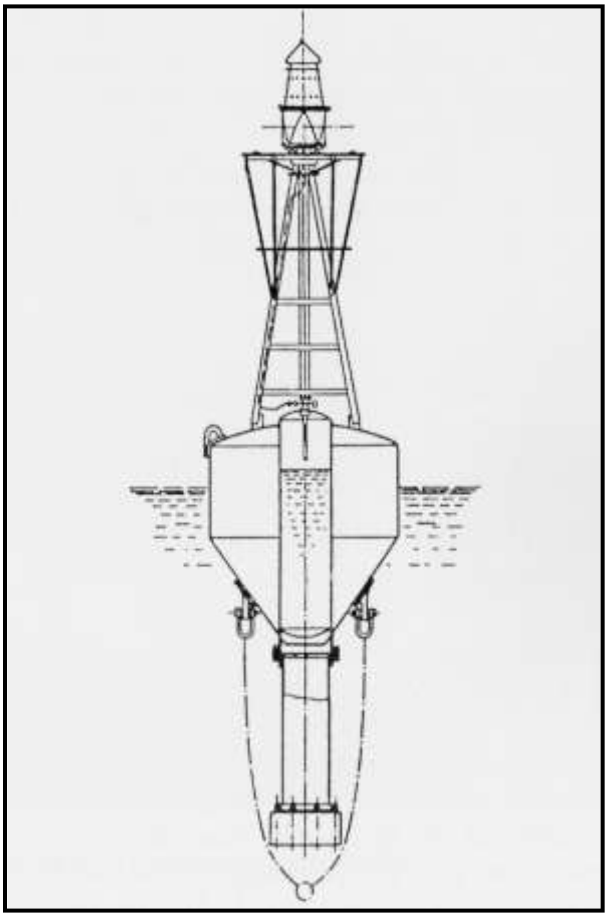


*Fig.63* AGA buoy lantern

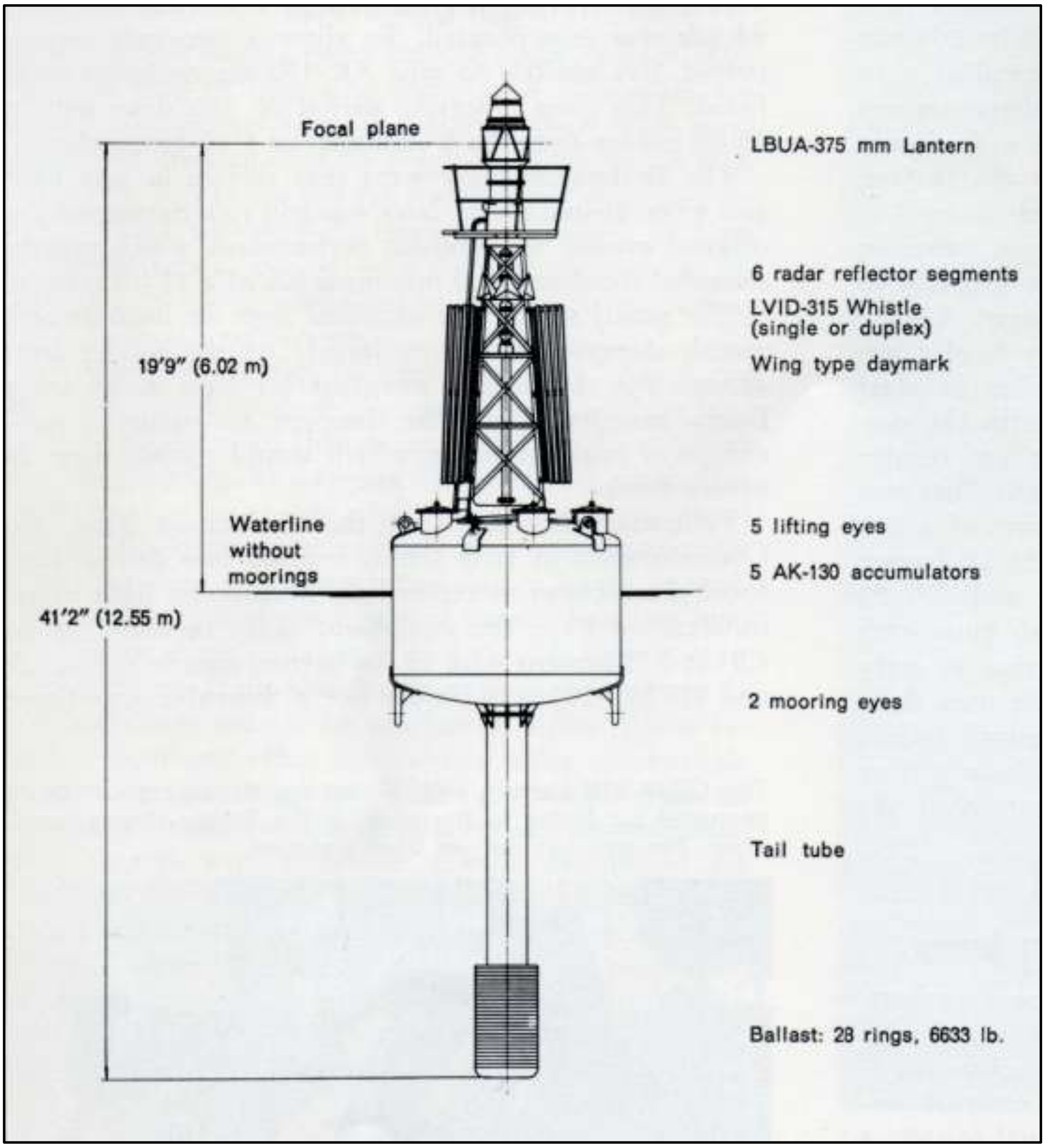
The AGA gas lanterns were to remain in use for nearly 100 years. Gustav Dalen received the Nobel Prize for Physics in 1912 for his contribution to the safety of navigation. 200 millimetre gas lanterns became standard equipment for many lighted buoys around the world with 375 millimetre lanterns with Dalen incandescent mantle burners being used on buoys of major navigational importance.

Figure 64 illustrates the size of the 375 millimetre Dalen lantern and Figure 65 illustrates the usual type of tail tube buoy that would be fitted with these lanterns. This drawing is from 1960 and includes a radar reflector on the buoy superstructure.

AGA sunvalves were used on some buoys. The sunvalve used solar radiation to operate a valve mechanism to switch off the gas supply during daylight and so reduce consumption. They were very costly and susceptible to damage on exposed stations which limited their use.

*Fig.64* 375 mm Dalen lantern
Lens not yet fitted

*Fig.65* AGA tailtube buoy with Dalen 375 lantern and whistle



## The worldwide use of gas buoys

Some countries continued to use oil gas until the late 1930s with authorities having their own gas distillation plants. As the commercial production of various petroleum based gasses (Liquid Petroleum Gas/LPG) developed, oil gas was gradually replaced with propane that could be stored in liquid form at moderate pressure.

As previously noted oil gas was usually stored directly within the buoy body and this process continued with LPG. The gas being transferred from storage tanks at the depot, into the buoy and in some services from storage tanks on the tender into the buoy on station. Later developments used LPG stored within dedicated gas cylinders. The empty cylinders were exchanged with full cylinders when necessary.

LPG gas lanterns and flashers developed in similar ways to acetylene lanterns. The world's lighthouse services divided between the use of acetylene or LPG as the gas for their buoys over a period of seventy years or so.

The Lighthouse Congress in Milan 1905 noted that there were 1317 lighted buoys worldwide with acetylene buoys used experimentally in USA, Canada and Scotland. The Philadelphia Congress of 1912 noted the introduction of incandescent mantles with oil gas lights. The Cairo congress in 1926 noted the competition between the French Barbier Bernard and Turenne (BBT) gas (LPG) system, the Pintsch systems and the AGA acetylene systems. The fast flash times that can be achieved with acetylene and the consequent character variations that are possible were especially noted, as was the greater reliability of the open flame acetylene lanterns compared with the LPG lanterns with mantles. *'Lively discussions'* were reported at the 1955 conference when the merits of acetylene, propane and the new electric buoy lights were compared.

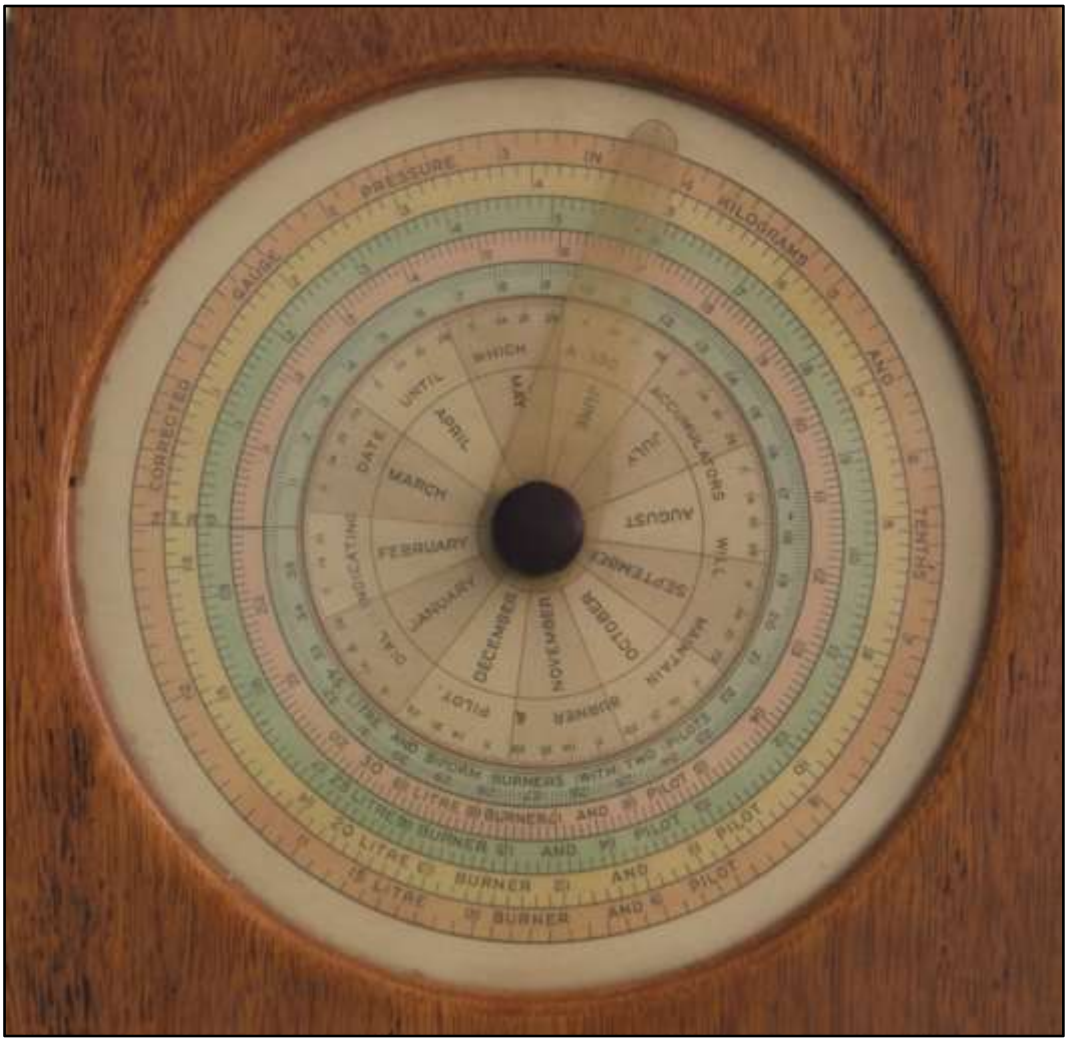
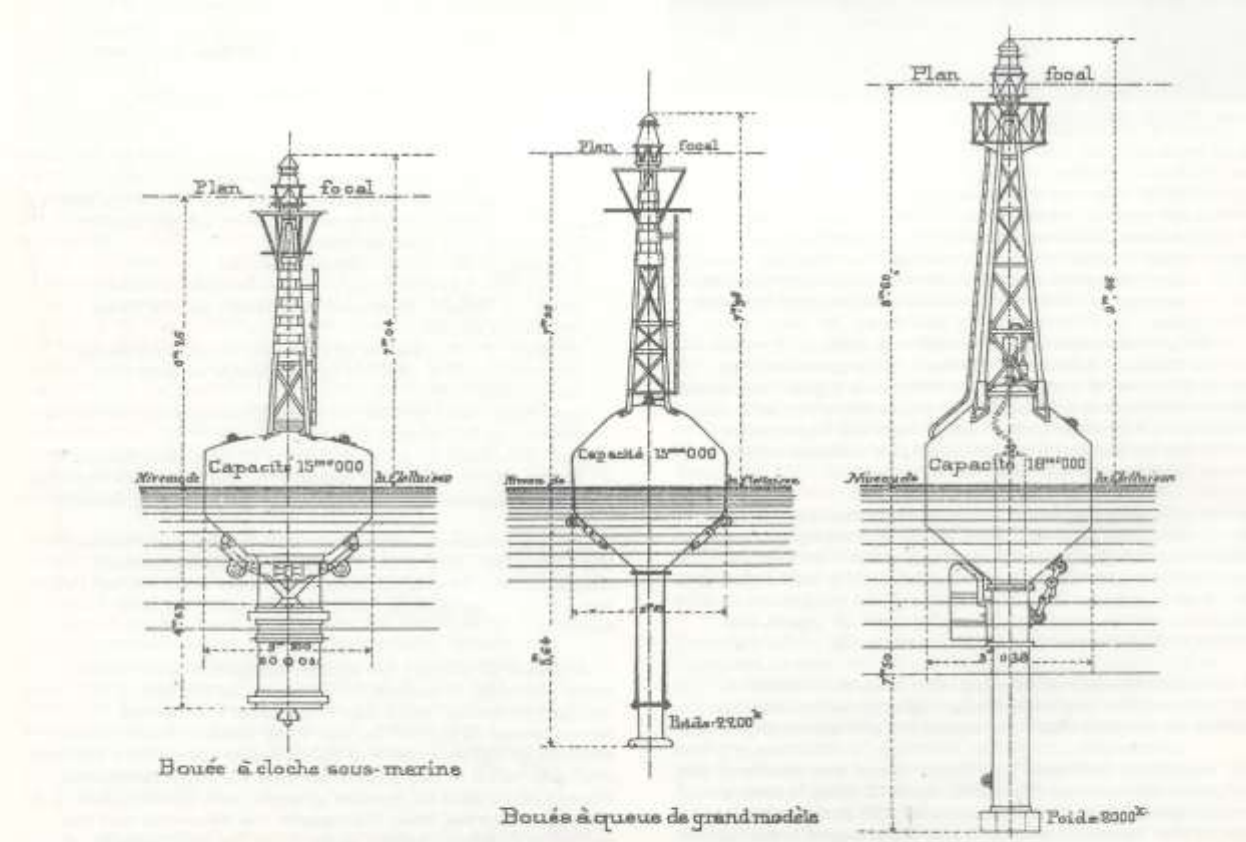



*Fig.66* Acetylene gas consumption calculator

The operating period of the buoy depended on the gas consumption of the character that the flasher was set to, the size of the burner and the volume gas remaining in the gas cylinder or buoy body. Gas consumption calculators took these variables into consideration.

Figure 67 below is from the 1912 International Navigation Congress in Philadelphia where buoy lighting with various types of gas was a major topic. The buoys are essentially similar to tail tube buoys still in use today. Note that one of the buoys has an under-water bell. This is an example of an almost forgotten area of floating aid technology, (see Chapter 6)




French lighted buoys

*Fig.67*

Gas lighting was almost universally used until the mid-1900s when some authorities started to change to primary battery powered lighting. Gas lanterns generally had better reliability than the early electric lanterns but the gas equipment was becoming very expensive. Electronically driven gas flashers were developed that consumed very little electrical power and opened up the possibility of switching the light off during daytime, to reduce gas consumption. These developments coincided with rapid developments in electronics and affordable solar panels that resulted in solar powered electric buoy lanterns becoming the lighting system to be chosen by most authorities. The introduction of the cardinal buoyage system in 1980s with the associated complex light characters proved problematic to operate with standard gas flashers. This hastened the change from gas to electric lights.

**Candela –** It is the international unit of luminous intensity.

# 6. FOG SIGNALS

In the later years of the 1800s fog bells and Courtney whistles (see Figure 30) were widely used on buoys.  The bells were usually fixed to the buoy structure and struck by suspended hammers that were moved by the rolling motion of the buoy.

*Fig.68* Wave actuated fog bell

Some bell buoys used rolling balls in guide tubes to strike the bell, see Figure 69.

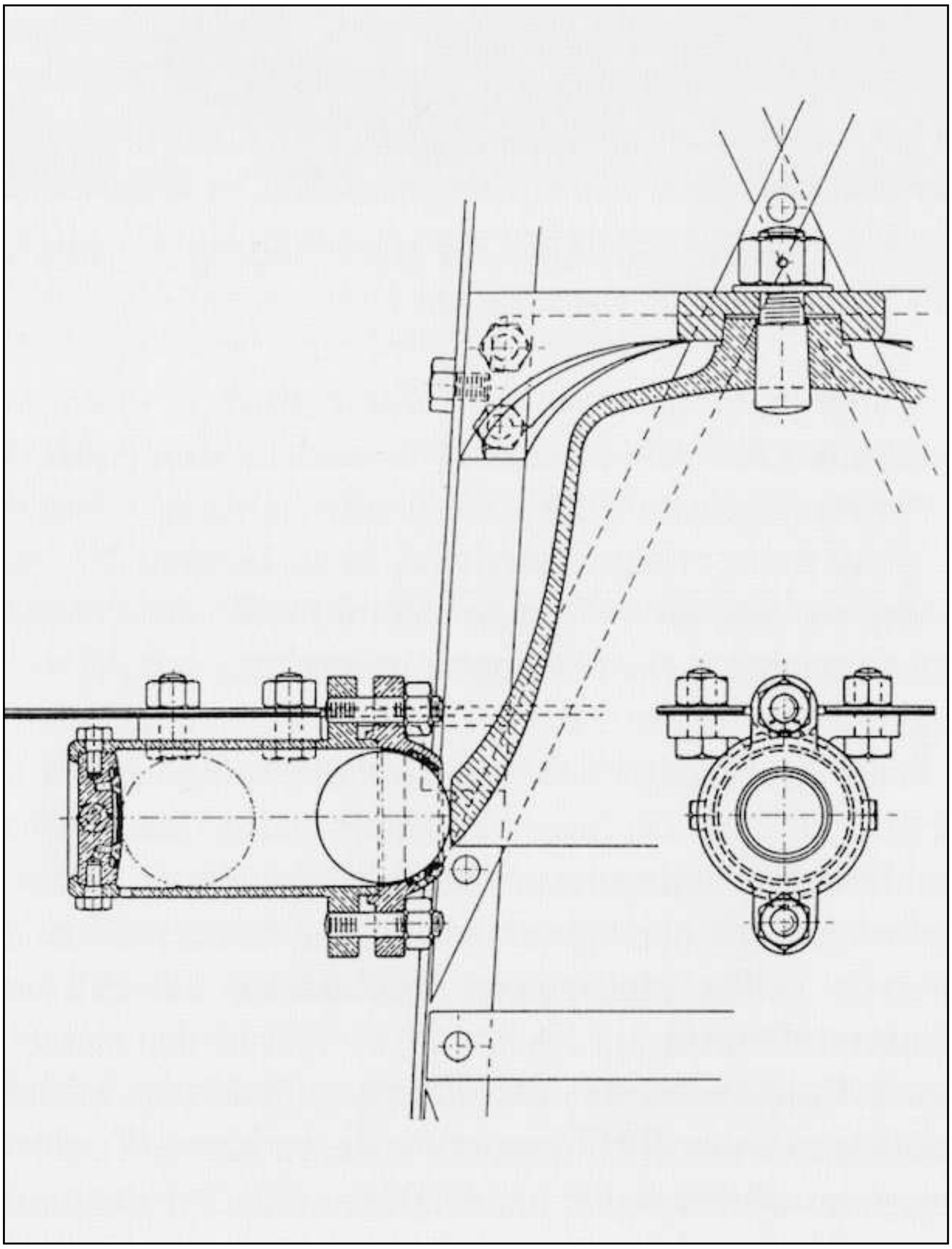


*Fig.69* Rolling ball fog bell

The Courtney whistle (see Figures 30 & 70) relies on the vertical heaving of the buoy to drive air through the whistle; hence both the bell and whistle depend entirely on local wave action to provide a random signal, or no signal in calm conditions.

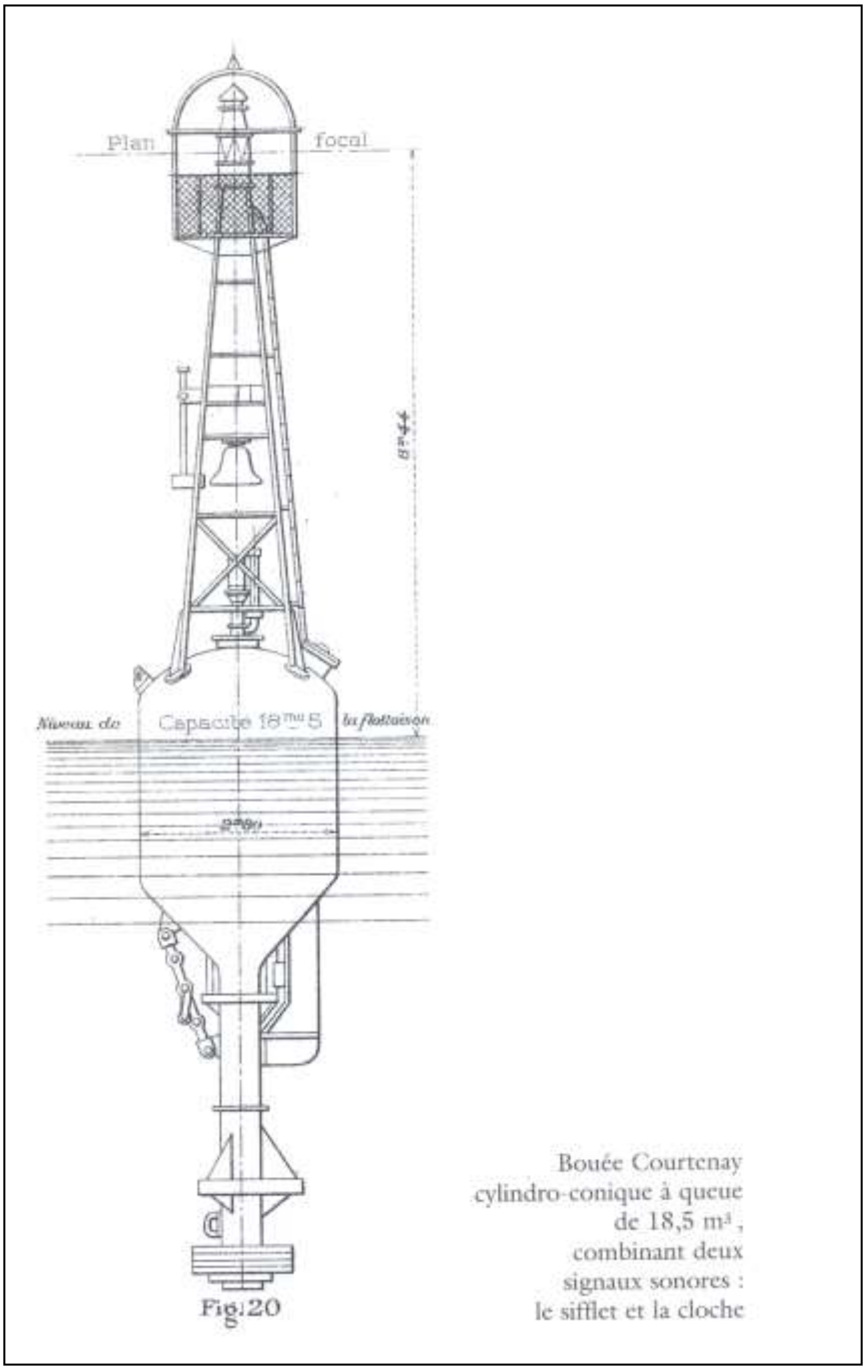



*Fig.70* French buoy with bell and whistle.

To provide a fog signal that would operate in all conditions Pintsch developed a coded fog bell striker that was driven by gas flowing through a flasher mechanism to then operate a piston that operated the bell striker.

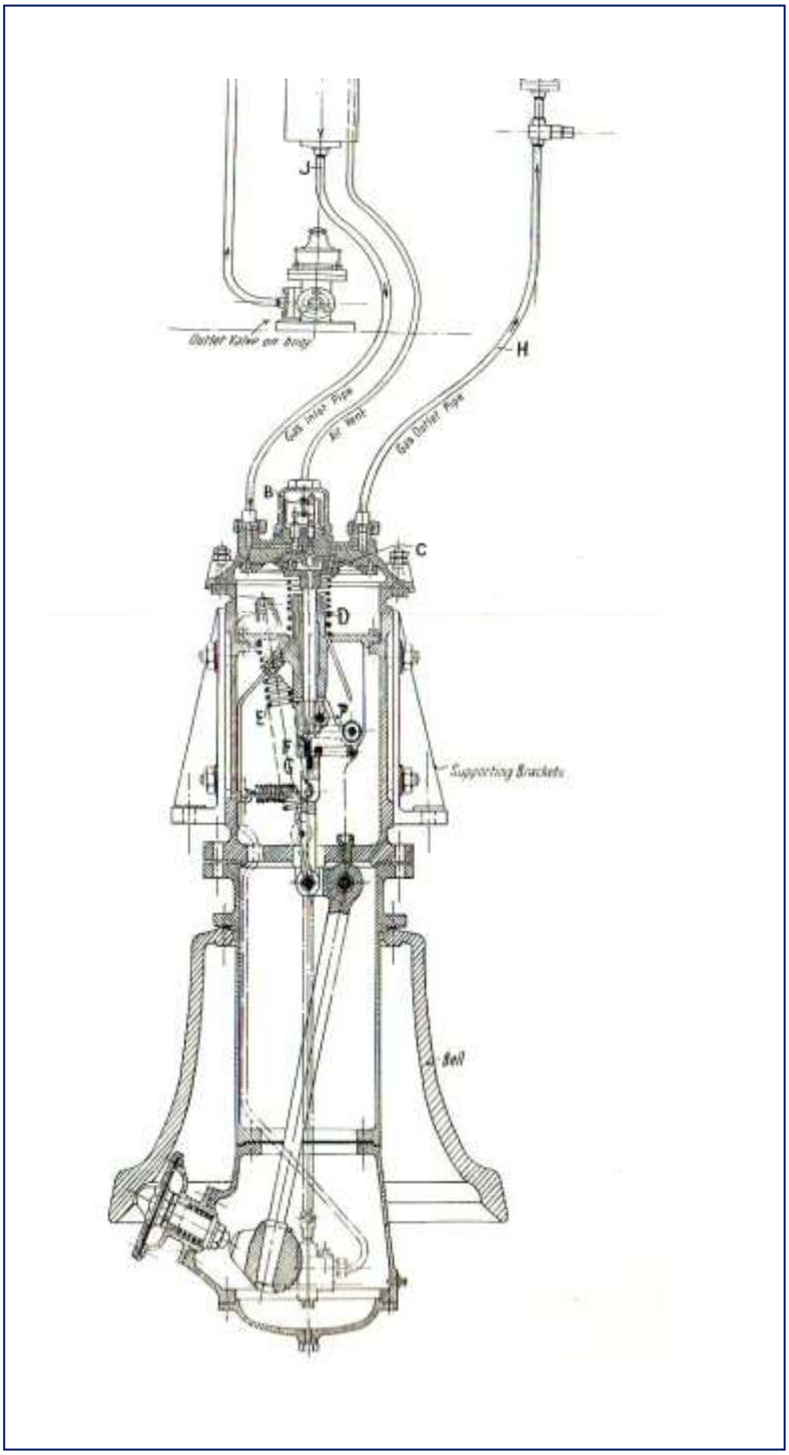



*Fig.71* Pintsch gas fog bell

Later developments by AGA resulted in carbon dioxide driven, coded fog bells that were widely used until the 1980s. The carbon dioxide was contained in cylinders stored in pockets in the buoy body and powered the fog bell and coder unit mounted in the buoy superstructure. The bell would operate continuously. The operating period depended on the sounding character and the available gas capacity. This was typically six months.

*Fig.72* AGA carbon dioxide fog bell

When primary battery systems came into used for buoy lighting, most of the commercial buoy equipment companies developed electric fog signals. These consisted of oscillator driven sound emitters, providing a coded signal for use at navigationally important buoy stations. The signals operated continuously and the battery packs required regular replacement.

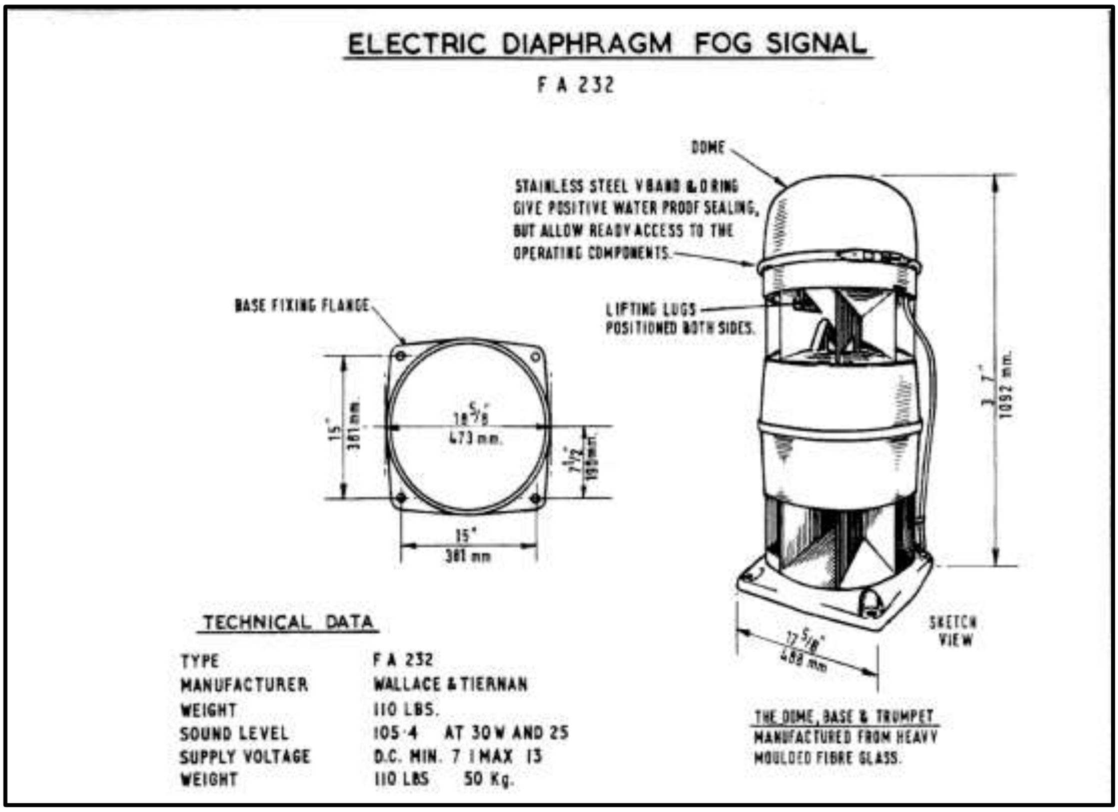



*Fig. 73*
Buoy fog signal

*Fig.74* Depth sounding 1904

It may be surprising that the fast steam vessels in the early 20th century had no on-board navigation aids beside their charts, compass, sextant, chronometer and leadline.

The Figure 74 shows a leadsman sounding the water depth on a battleship in 1904. Some assistance in position finding was provided with the introduction of submarine bells. These take advantage of the fact that sound travels much faster in water than in air and the reflection and refraction problems that make sound propagation in air so uncertain have little effect on propagation in water. Large ships were equipped with underwater listening devices (hydrophones) that could detect underwater bells at a range of ten miles and make a good estimate of the direction of the bell.

In the early 1900s underwater buoy bells were operated by the rolling motion of the buoy and were thus dependant on sea state. Lightvessels had underwater bells that were mechanically operated and later electrical oscillators, (1923 in US service). These could be synchronised with the lightvessel's main fog signal (whistle, siren or diaphone). The approaching ship could then note the time difference between the reception of the airborne signal and the under-water signal and be able to accurately calculate, for the first time, their distance from the lightvessel. This principle was further developed when the underwater fog signals were synchronised with the first radio beacons.

The 1929 London International Lighthouse Conference noted that underwater fog signals were of particular use to fishing vessels and small craft, (the underwater fog signal presumably being heard through the vessel's hull), however at this time it was evident that radio beacons would probably supersede the underwater signals.

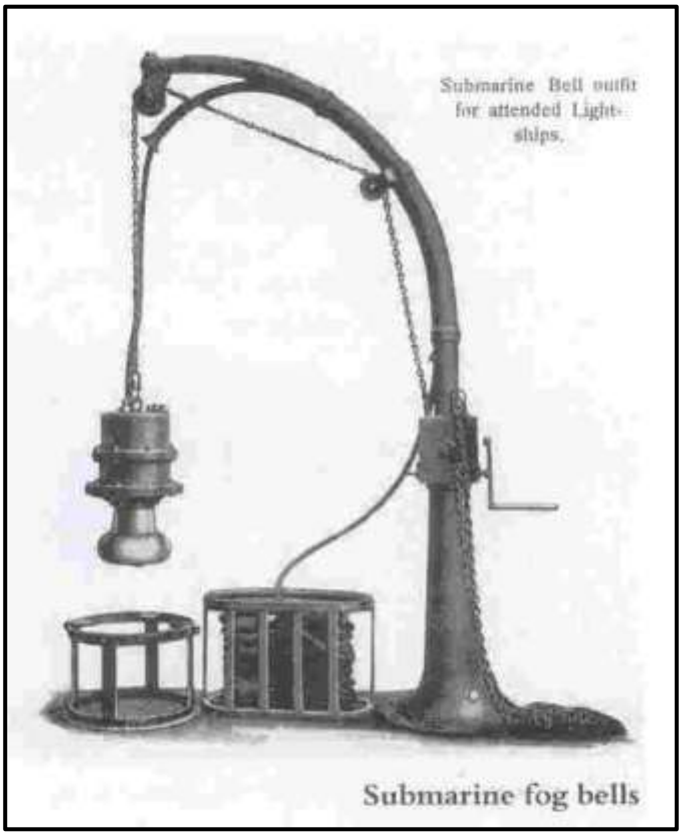



*Fig.75* Lightvessel submarine fog bell that would be lowered into the water and sounded in conditions of poor visibility.

# 7. ELECTRIC BUOY LIGHTS

The very early trials of electric buoy lighting, operated from sea bed supply cables, were all unsuccessful. Developments in robust low voltage lamps and primary batteries resulted in the concept of electric buoy lighting being discussed at the World Lighthouse Service conference in 1937. Some services then changed from gas buoy lights to primary battery powered electric lights in the 1950s and 1960s. Flash characters could be switched, initially by electromechanical flashers and later by electronic coders and the lights switched off during daylight by photocells. However there was still the requirement for the regular visits to the buoy for replacement of the primary battery packs.

Coloured light was produced by the use of coloured filters with a consequent considerable loss of light output.

*Fig.76* German lantern and battery pack
1941

Small electric lamps were never entirely reliable at exposed buoy stations due to the inherent fragile nature of the incandescent lamp filament. Various forms of automatic lampchanger were developed to address this problem, however they introduced problems of their own associated with moving contacts, vibration, corrosion etc.

An alternative concept was developed in the form of the twin filament lamp. One filament operated as the main filament with the second filament being automatically switched on if the first should fail.

*Fig.77* A selection of early lamp changers and flashers displayed in the USCG Aids to Navigation Training School museum.

*Fig.78* A seventeen position lamp changer in the USCG Aids to Navigation Training School museum.


*Fig.79* A collection of lamp changers from the 1980s in the Hurst Castle museum (UK)

Early electric lanterns were essentially similar to gas lanterns without the ventilation required for a gas burner. They developed at the same time as optical plastics were being developed. 150 millimetre plastic lensed lanterns became standard for the majority of buoy use with 250 or 300 millimetre lenses for long range lights. Such lanterns were considerably lighter than their gas predecessors making them simpler to mount and easier to handle.

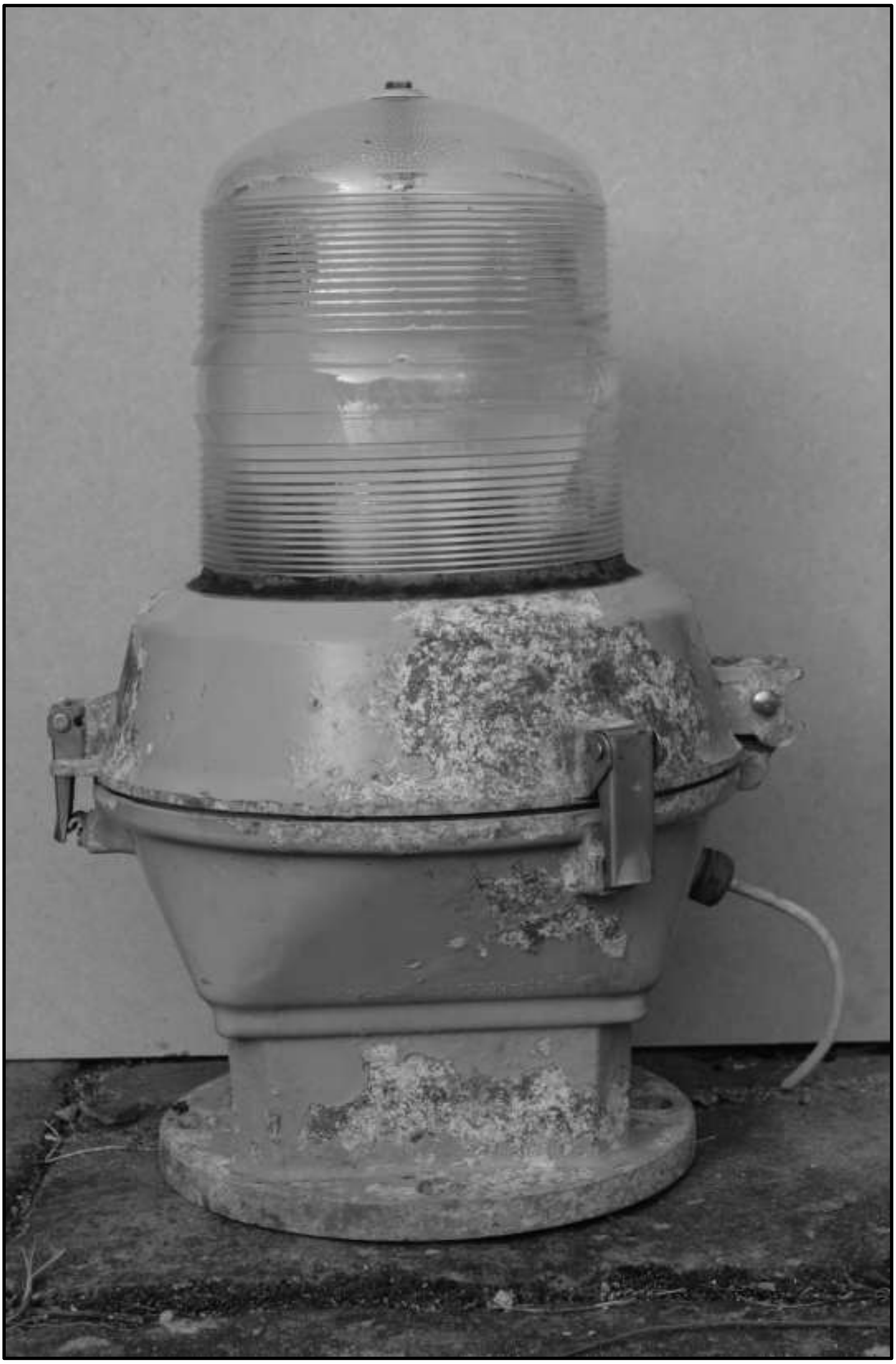


*Fig.80* Early Pintsch 150 millimetre electric lantern with moulded glass lens.

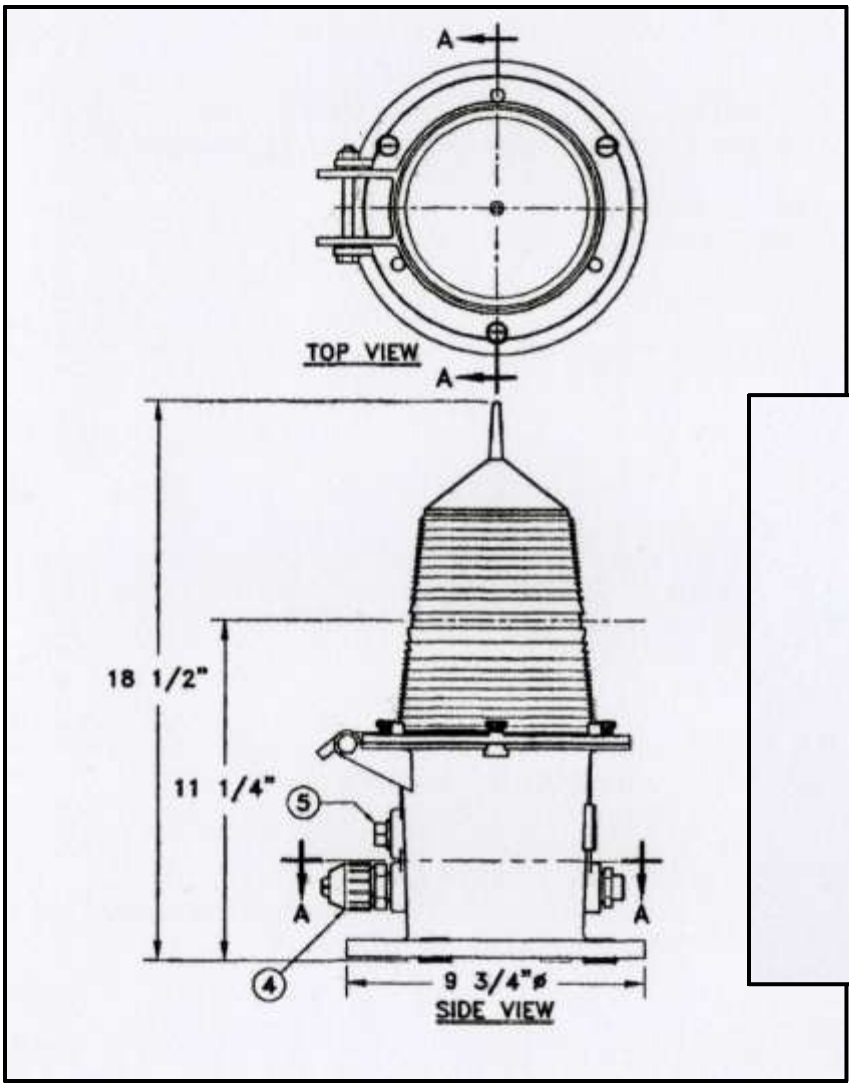
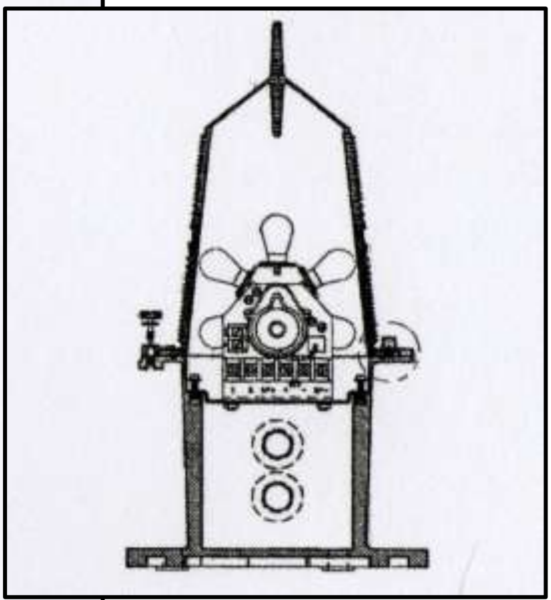



*Fig.81* 155millimetre lantern with plastic lens and body
Section shows six position lampchanger



**Alternative electric power supplies**

Some authorities had used secondary batteries that were regularly recharged by the servicing vessel but these had relatively short service periods and a history of serious accidents due to the accidental ignition of battery gases during the charging process.
Various means were tried to generate electrical power on the buoy.
Limited success was found with sea water batteries. These required very large areas of electrode immersed in the sea water and suffered corrosion and marine fouling problems.

Turbine generators achieved some success and remain in use in several countries. These utilise a turbine driven alternator mounted at the top of a tube passing through the buoy (similar to the tube in a whistle buoy). The heaving motion of the buoy then drives air through the turbine.

Regular maintenance of the turbine is required and the system is vulnerable to marine fouling.

In the 1960s there was interest in the peaceful use of nuclear power. Small power packs were developed that utilised Strontium 90 to activate thermoelectric couples. They were designed to operate for more than ten years. Encapsulated in radiation shielding they weighed about 1000 kilos and could fit into a typical three metre buoy body. The US project was called *Ensign Peaceful Atom.* The UK project was *Ripple X* and a similar device was used in the USSR. The hazards of having nuclear devices floating in the ocean were soon realised and the projects disbanded.

## Solar power

The introduction of solar modules to recharge secondary batteries was probably the most significant step in lighted buoy technology. There were progressive solar module developments in the 1980s and the problems of mounting solar modules, charge regulation and choice of battery type were solved and confidence was gained in the long term operation of solar systems. Many gas buoys and primary battery buoys were then converted to solar power with electric lanterns. There was then no need for ships to change heavy gas bottles or replace packs of primary batteries, however regular service visits were still required to replace filament lamps.


*Fig.82* Trinity House solar buoy 1990

## Light emitting diode (LED) lighting

Solar power systems soon demonstrated their reliability and the next development was the LED lantern. The LED semiconductor junction provides a very efficient conversion of electrical power to light. The LED will last for many years and consequently the need to regularly replace filament lamps, on station has gone. There is the added advantage that the light output of coloured LEDs are equal or better than white LEDs, this is compared with coloured light produced by filtering light from a filament lamp where 30% to 50% of the light is lost in the filter. The long life of LEDs being equal to the anticipated total life of the complete lantern has allowed lantern design to change so that the lantern is a completely sealed unit as it is no longer necessary to replace lamps.

*Fig.83* Early red LED buoy lantern

These factors combined with the greater efficiency of LEDs when compared with filament lamps has resulted in smaller solar modules being required to power a given light output so that for short range lights the lantern can be combined in one housing with the solar modules and battery.

*Fig.84* Small self-contained 1.2 cd
LED lantern

# 8. RADIO AIDS

Radio beacons became an important aid for ships; to fix their position when offshore and also when close to the shore in conditions of poor visibility. They were first installed on lightvessels in the 1920s. These provided plenty of work for the crews maintaining the wire aerial systems on vessels that would be rolling and pitching heavily in bad weather.

When radar came into use on merchant vessels, the effectiveness of simple passive radar reflectors was proven and the majority of important buoy stations were fitted with 'corner' radar reflectors in the 1950s.

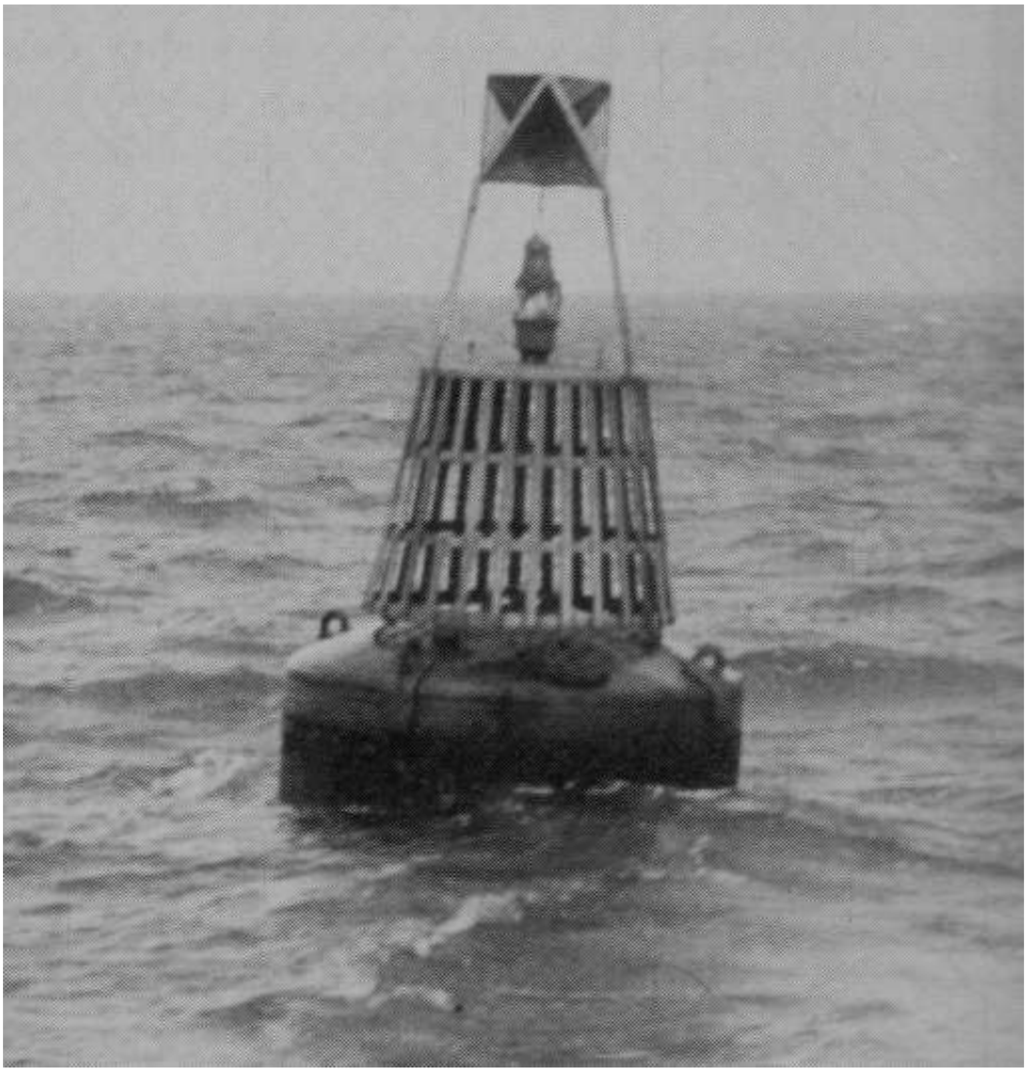


*Fig.85* Early Radar reflector
on acetylene gas buoy.

It was important that the radar reflector should be mounted as high as possible and the decision had to be made if the light or the radar reflector should be at the top of the buoy. Early installations with the reflector high above the lantern suffered considerable damage in bad weather.

Robust radar beacons (Racons) were developed that could be mounted on buoys and provided another aid to navigation that should be mounted as high as possible in the superstructure. These were however quite heavy and also very costly. They were generally mounted in a secure position within the superstructure to give some protection from impact.

Racons were first used before solar power systems were generally in use and so required dedicated primary battery packs for their power. The life of the battery pack then determined the service life of the buoy. This could be difficult to predict as the power consumption of the Racon depended on the frequency of its interrogation by the radars of passing ships.

The introduction of AIS in recent years has provided another class of aid that requires the AIS aerial to be mounted as high as possible on the buoy structure. As AIS requires modest power it can operate from solar charged batteries, the exception being at high latitudes because of low solar radiation. Also of light weight, the AIS provides a uniquely long range aid to navigation for a buoy to carry.


*Fig.86* Large solar powered buoy with Racon, LED lantern and AIS installation.

# 9. VERY LARGE BUOYS

The concept of very large buoys was established early on with the French high focal plane tailtube oil gas buoys replacing lightvessels in the 1890s.

*Fig.87* French BBT high focal plane buoy early 1900s

These very large tail tube buoys were difficult to handle with the modestly sized service vessels then in use. The buoys' performance in fast tidal streams was also problematic. Lightfloats were generally used in fast flowing tidal situations where buoy equipment was mounted on a boat shaped hull.

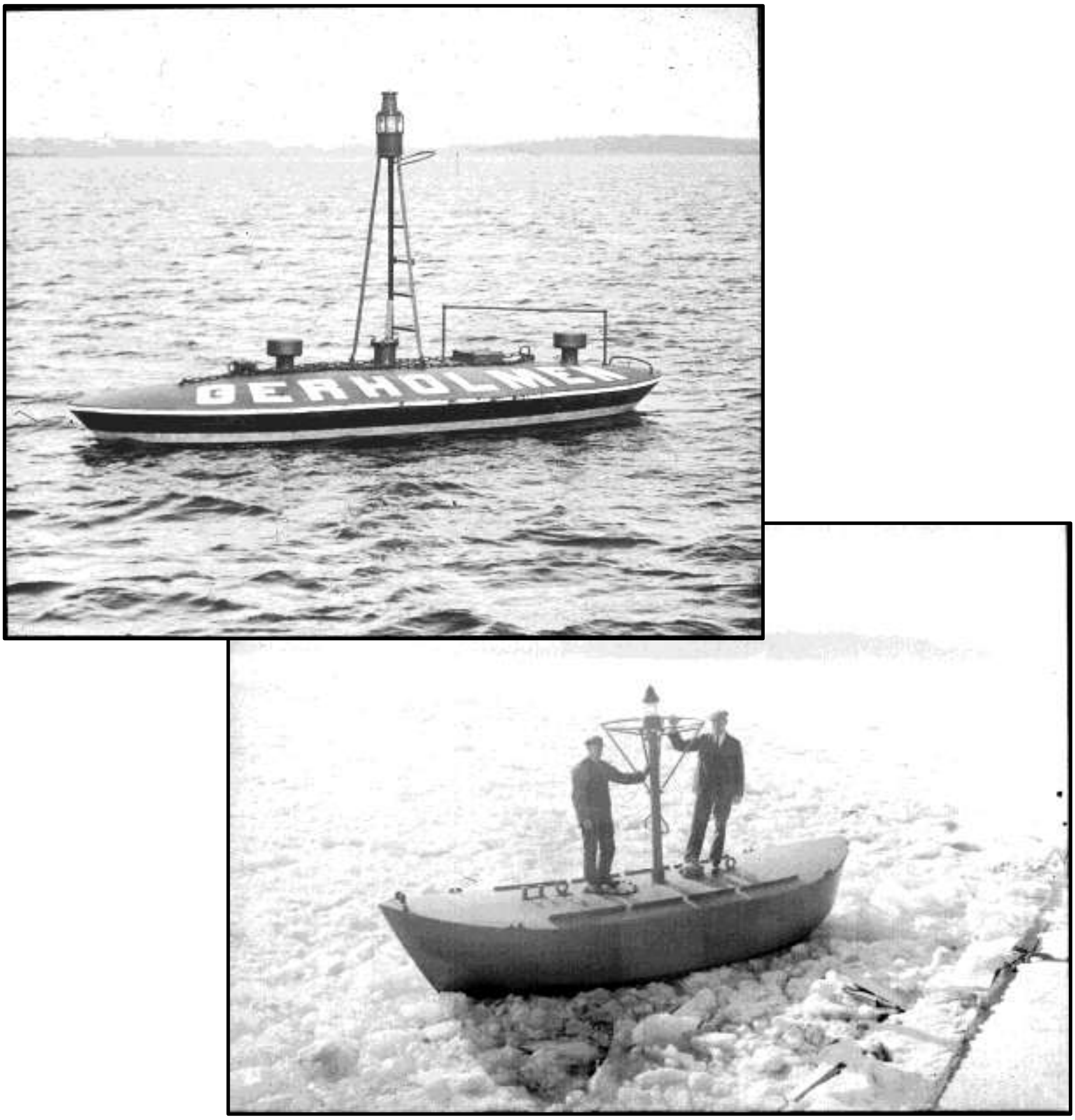



*Fig. 88* Lightfloats

The next major advance in large buoy technology did not take place until the 1970's when the US Coastguard made the decision to replace manned lightvessels with remotely monitored very large buoys.


*Fig.89* USCG LANBY buoy April 1971

These Large Automatic Navigation Buoys (LANBYs) were 13 metre diameter very shallow hulls with 13 metre towers. They were developed from a meteorological buoy designed for open ocean operation. The hull contained fuel tanks, two long running diesel alternators to power the light and fog signal and very large cabinets of electrical control equipment and radio systems.

The original US LANBY buoys and those built later in the UK proved generally unreliable and very difficult to maintain on station.

*Fig.90* LANBY IALA 'Floataid' Dublin 1984

The engineering effort that went into solving the problems highlighted by the first LANBYs eventually established confidence in the operation of remotely operated diesel power systems, remote control and monitoring systems and unattended moorings. This led to the steady automation of the manned lightvessel fleet and the offshore lighthouses.


*Fig.91* Trinity House tender operations 1990

In Figure 91 we see a tender removing one automated lightvessel from station and about to replace it with a newly refitted vessel. Note that the buoys on deck have no lanterns fitted. The acetylene gas lanterns will be operating in the lantern test space on the foredeck to ensure their characters are correct and will only be fitted to their buoys just before laying. The sea time of the tender fleet will have been substantially reduced as they no longer have to carry crews and their supplies to lightvessels and offshore lighthouses as many of these have been automated but in 1990 they are still re-gassing buoys, re-fuelling the lightvessels and maintaining moorings.

# CONCLUSION

The majority of new buoys are now made from some form of moulded plastic with a steel structural core and possibly an aluminium superstructure, rather than the riveted steel structure of 100 years ago. However in the past 300 years mooring methods have changed very little. We still use steel chains and cast iron or concrete sinkers. Regular, if less frequent, inspection and cleaning is still required to remove salt deposits and bird fouling from the daymark, solar panels, lantern, racon and AIS. Weed growth has also to be removed from the buoy body.

Low powered aids to navigation technology has enabled the conversion of the few remaining lightships to solar power. It will be interesting to see how many and what types of floating aids to navigation will remain at the end of this century.