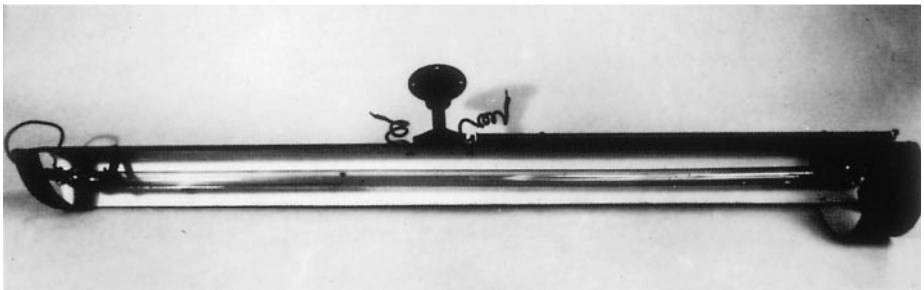
Cooper-Hewitt's low-pressure mercury lamp. This lamp worked much like a modern-day fluorescent tube but did not contain any fluorescent material, so only very little visible light was produced. The lamp was mounted in the centre like a scale beam, because it was ignited by tipping the tubes by means of a drawstring.



Theatre foyer lit by Moore lamps.

all Heinrich Goebel, who in 1854 produced incandescent lamps with a service life of 220 hours with the aid of carbonized bamboo fibres and air-void eau-de-cologne bottles.

The actual breakthrough, however, was indeed thanks to Thomas Alva Edison, who in 1879 succeeded in developing an industrial mass product out of the experimental constructions created by his predecessors. This product corresponded in many ways to the incandescent lamp as we know it today – right down to the construction of the screw cap. The filament was the only element that remained in need of improvement. Edison first used Goebel's carbon filament comprising carbonized bamboo. Later synthetic carbon filaments extruded from cellulose nitrate were developed. The luminous efficacy, always the main weakness of incandescent lamps, could, however, only be substantially improved with the changeover to metallic filaments. This is where Auer von Welsbach, who had already made more efficient gas lighting possible through the development of the incandescent mantle, comes into his own once again. He used osmium filaments derived through a laborious sintering process. The filaments did not prove to be very stable, however, giving way to tantalum lamps, which were developed a little later and were considerably more robust. These were in turn replaced by lamps with filaments made of tungsten, a material still used for the filament wire in lamps today.

Following the arc lamp and the incandescent lamp, discharge lamps took their place as the third form of electric lighting. Again physical findings were available long before the lamp was put to any practical use. As far back as the 17th century there were reports about luminous phenomena in mercury barometers. But it was Humphrey Davy once again who gave the first demonstration of how a discharge lamp worked. In fact, at the beginning of the 18th century Davy examined all three forms of electric lighting systematically. Almost eighty years passed, however, before the first truly functioning discharge lamps were actually constructed, and it was only after the incandescent lamp had established itself as a valid light source, that the first discharge lamps with the prime purpose of producing light were brought onto the market. This occured at around the turn of the century. One of these was the Moore lamp – a forerunner of the modern-day high voltage fluorescent tube. It consisted of long glass tubes of various shapes and sizes, high voltage and a pure gas discharge process. Another was the low-pressure mercury lamp, which is the equivalent of the fluorescent lamp as we know it today, except that it had no fluorescent coating.

American light tower
(San José 1885).

The Moore lamp – like the high-voltage fluorescent tube today – was primarily used for contour lighting in architectural spaces and for advertising purposes; its luminous intensity was too low to be seriously used for functional lighting. The mercury vapour lamp, on the other hand, had excellent luminous efficacy values, which immediately established it as a competitor to the relatively inefficient incandescent lamp. Its advantages were, however, outweighed by its inadequate colour rendering properties, which meant that it could only be used for simple lighting tasks.

There were two completely different ways of solving this problem. One possibility was to compensate for the missing spectral components in the mercury vapour discharge process by adding luminous substances. The result was the fluorescent lamp, which did produce good colour rendering and offered enhanced luminous efficacy due to the exploitation of the considerable ultra-violet emission.

The other idea was to increase the pressure by which the mercury vapour was discharged. The result was moderate colour rendering, but a considerable increase in luminous efficacy. Moreover, this meant that higher light intensities could be achieved, which made the high-pressure mercury lamp a competitor to the arc lamp.

1.1.5 Quantitative lighting design

A good hundred years after scientific research into new light sources began all the standard lamps that we know today had been created, at least in their basic form. Up to this point in time, sufficient light had only been available during daylight hours. From now on, artificial light changed dramatically. It was no longer a temporary expedient but a form of lighting to be taken seriously, ranking with natural light.

Illuminance levels similar to those of daylight could technically now be produced in interior living and working spaces or in exterior spaces, e.g. for the lighting of streets and public spaces, or for the floodlighting of buildings. Especially in the case of street lighting, the temptation to turn night into day and to do away with darkness altogether was great. In the United States a number of projects were realised in which entire towns were lit by an array of light towers. Floodlighting on this scale soon proved to have more disadvantages than advantages due to glare problems and harsh shadows. The days of this extreme form of exterior lighting were therefore numbered.

Both the attempt to provide comprehensive street lighting and the failure of these attempts was yet another phase in the application of artificial light. Whereas inadequate light sources had been the main problem to date, lighting specialists were then faced with the challenge of purposefully controlling excessive amounts of light. Specialist engineers started to think about how much light was to be required in which situations and what forms of lighting were to be applied.

Task lighting in particular was examined in detail to establish how great an influence illuminance and the kind of lighting applied had on productivity. The result of these perceptual physiological investigations was a comprehensive work of reference that contained the illuminance levels required for certain visual tasks plus minimum colour rendering qualities and glare limitation requirements.

Although this catalogue of standards was designed predominantly as an aid for the planning of lighting for workplaces, it soon became a guideline for lighting in general, and even today determines lighting design in practice. As a planning aid it is almost exclusively quantity-oriented and should, therefore, not be regarded as a comprehensive planning aid for all possible lighting tasks. The aim of standards is to manage the amount of light available in an economic sense, based on the physiological research that had been done on human visual requirements.

The fact that the perception of an object is more than a mere visual task and that, in addition to a physiological process, vision is also a psychological process, was disregarded. Quantitative lighting design is content with providing uniform ambient lighting that will meet the re-quirements of the most difficult visual task to be performed in the given space, while at the same time adhering to the standards with regard to glare limitation and colour distortion. How we see architecture, for instance, under a given light, whether its structure is clearly legible and its aesthetic quality has been enhanced by the lighting, goes beyond the realm of a set of rules.

1.1.6 Beginnings of a new kind of lighting design

It was, therefore, not surprising that alongside quantative lighting technology and planning a new approach to designing with light was developed, an approach that was related far more intensely to architectural lighting and its inherent requirements.

This developed in part within the framework of lighting engineering as it was known. Joachim Teichmüller, founder of the Institute for Lighting Technology in Karlsruhe, is a name that should be mentioned here. Teichmüller defined the term "Lichtarchitektur" as architecture that