



**The Design, Installation and Maintenance of  
IN-PAVEMENT  
AIRPORT LIGHTING**



**JAQUITH  
INDUSTRIES INC.**

**By Arthur S. Schai  
F.I.E.S.**

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## About The Author

The, author, Arthur S. Schai, is president of Schai Associates, Inc., Consultants for Airport Lighting Installation. Mr. Schai was Senior Vice-President of Vega Industries Inc. until 1977. He is known internationally as "The Old Man of the Airport Lighting Industry." He was a pioneer in inset lighting and has been involved as a consultant to consultants in airport lighting for over a quarter of a century. He has participated, in some way, in almost every installation worldwide that used inset lighting, including the NASA Space Shuttle runway at Cape Canaveral, Fla.

Educated at Carnegie Institute of Technology, he is a Fellow of the Illuminating Engineering Society, of which he is a past chairman of its Aviation Committee. He has presented many technical papers, lectured to industry and college groups and participated in ICAO seminars on airport lighting in many parts of the world. He is an adviser-member of the ICAO study group on Frangibility. He was awarded the FAA Achievement Award in 1973, the citation of which read in part "... his initiative, untiring efforts and technical skill have enhanced aviation safety through the development of safe, efficient and economical Airport Lighting Equipment and Techniques..."

He has served on the Handbook Committee of the Illuminating Engineering Society, as well as Chairman of its Government Contact Sub-Committee and a member of the Joint Nasao-I.E.S. Standards Committee. He recently participated as a member of a Lighting Industry People-to-People Visitation to The People's Republic of China for the presentation of American Lighting Material, Methods and Usage.

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The many Airport Engineering Departments, Consultants and Installers who, in their daily work, contributed many innovations, procedures, methods and suggestions that resulted in safe, efficient and successful airport lighting systems all over the world.

# Foreword

This document's purpose is to explain how to successfully design and construct a trouble-free, pavement-integrated, inset lighting system.

To sharpen our focus, we will consider only those inset lights subject to impact by aircraft or vehicular traffic on an airport. The lights included in the discussion are: Runway Centerline, Touchdown Zone, Taxiway Centerline, Displaced Threshold, Displaced Approach, High-Speed Exit, Hold Bars, Semi-Flush Edge and Apron Lead-In lights as well as other equipment integrated into the pavement.

The document begins by providing a technical and historical perspective on the subject of in-pavement lighting and it progresses to more specific information on current technology, applications and installation methods.

Throughout, the document's aim is to provide a comprehensive discussion on the subject and to help designing engineers, airport operators and installation personnel make technically informed decisions.



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# **Background on In-Pavement Airport Lighting**

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Introduction  
Early In-Pavement Lights  
Early Installations  
New Installation Techniques  
Various Lights and Their Functions  
Other Points of Concern  
Planning and Designing the System  
Paving Materials and Techniques

## Introduction

Very soon, we will have the ability to land aircraft under category III conditions. Already, some commercial, military and space vehicles are equipped with "fly by wire" systems that permit landings under zero visibility. But practical limitations such as cost, universal availability and need for human backup will make visual aids necessary to aviation for many years.

Among the key landing and ground-movement visual aids are those located in the pavement of runways and taxiways. These lighted aids are needed for landing, rollout, take-off, ground-movement, traffic control and high-speed exits from runways and apron guidance for docking. During the fifteen years in which this kind of lighting was being installed, techniques were developed to make its installation compatible with paving requirements yet without compromising the integrity and function of the lights.

## Early In-Pavement Lights

The Alfaka light was an early attempt at in-pavement lighting. The Alfaka light was housed in an opening in the runway covered by a steel grate. Below the grate, par-lamp fixtures were set at an angle that made their light visible to a pilot during landing. In low-visibility conditions the light indicated the area of runway the aircraft should contact.

The Alfaka light developed visibility problems due to accumulated water and snow and it was expensive to install and maintain. These drawbacks led to the development of individual semi-flush lighting fixtures. The first semi-flush lights were epoxied into the pavement and were called "pancake lights." They consisted of a metal body containing quartz-iodide lamps placed in a metal container. The lamps were protected by a heavy metal cover that contained an aperture through which the light escaped. Pancake lights, though relatively inexpensive lacked the quality of light emission provided by a lens system.

One of the early successful semi-flush lights was the F.A.A. L-838 fixture. It was 12 in. in diameter and was used for threshold and approach lighting. The L-838 used a par-56 lamp inside a steel housing and involved an optical system that beamed light at an angle that made the light visible to the pilot.

With the advent of heavier and faster jet aircraft came the need for in-pavement runway centerline and touchdown-zone lights and these led to the development of the F.A.A. L-842 centerline light. This light's 8-in. diameter cast-metal base was epoxied into the pavement. The base housed a fixture that was bolted to it and that had a lens system with a 45-watt quartz-iodide lamp. A variation of the L-838 was also used. With an F.A.A. designation L-845, this larger light had a diameter of 10 in. and was powered with a 45-watt quartz-iodide lamp mounted on a heavy fabricated-steel transformer base with access for the primary conductors near the bottom.

The F.A.A. L-843 touchdown-zone light developed at this time was a 200-watt quartz-iodide light and lens system housed in heavy casting. The L-843 could be mounted in a shallow cast base or on a F.A.A. L-837 deep-marker light base using an adapter to fit the base's top flange.

The L-843 and L-845 were probably the first fixed-azimuth inset lights to be used in monolithic fashion.

### **Early Installations**

Before monolithic paving techniques, however, inset light fixtures were installed by coring a shallow opening in the existing pavement and then bonding the fixture to the pavement with an epoxy or polyester adhesive. Kerfs wide enough to accommodate the wires were sawed into the pavement and the conductors were laid in and covered with the epoxy or polyester material. Several assumptions, since revised, were made at this time:

- 1) that most installations would be made in existing runways and taxiways
- 2) that the adhesive would perform on all types of pavements
- 3) that the precision needed to adjust the light's azimuth and elevation settings relative to the surface could be achieved only by having the surface as a reference.

Heavier and heavier jets, coupled with the failure and incompatibility of the sealant with some paving materials, soon made airport operators reconsider. Despite the improvement in low-visibility operations, costs increased greatly due to maintenance, lamp outages and damage to equipment and runways. Civil engineers questioned whether sawing and coring perfectly good runways to make inset lights possible justified the expense of weakening the runways. The lighting engineer had in essence asked the paving engineer to compromise his craft to meet the lighting engineer's sophisticated needs.

By 1963, the advent of the large jets foreshadowed the wave of reconstruction and newly built runways and taxiways. Several abortive attempts were made to incorporate inset lights in the pavement. These were moderately successful at best and the engineers involved had difficulty meeting the necessary close tolerances.

### **New Installation Techniques**

In 1967, Reinard Brandley, Consulting Engineer for the City of Sacramento, California, took a critical step toward establishing modern installation methods. When planning to install centerline lighting, Brandley decided that the time had come to switch to a conduit system--a system much more dependable than one whose conductors were buried in saw cuts at the surface. In view of this, Brandley designed Sacramento Airport with a conduit buried in the compacted subbase. After the flexible runway was paved, cores were made at the inset light stations. The cores were about three feet in diameter and they were drilled to the subbase, exposing the steel conduit. This was cut within the hole and connected to a steel transformer base. The base was supported by a jig to make the centerline light flush with the surface and to insure the proper azimuth. The opening below and around the base was back-filled with an expanding cement concrete of adequate strength. Compared to a glue-in system, this new system demonstrated greater reliability and reduction in lamp outages and maintenance costs.

The need for increased reliability and reduced costs prompted a similar step forward in 1968, at Chicago's O'Hare Airport. O'Hare's operators, faced with the impending jumbo-jet traffic, decided that existing epoxied wireways and shallow glue-in L-850 centerline light fixtures in some runways failed to justify their expense. The operators of O'Hare planned a monolithic in-pavement installation of the centerline system for runway 14R. The rigid P.C.C. runway was placed over a compacted base, which contained a steel cylinder, or hoop, with conduit hubs located 180 degrees apart on the sides of the hoop and with the conduit attached to the hubs. After paving, the 16 in. thick concrete slab was step-cored at the light stations with a 24 in. and 22 in. diamond core-drill. The top section of the base was then fastened to the hoop and the hole around the assembly was back-filled with concrete. The light was attached to the flange of the steel base, flush with the surface of the pavement.

A year later, in 1969, the Los Angeles International Airport designed runway 24R to include L-850 centerline lights. These would be supported by type II light bases (at the time, new) cast monolithically in P.C.C. pavement 16 in. thick. The bases were to be connected by a 2-in. diameter steel conduit placed in a chase in the compacted subbase. The plan called for replacing and compacting the subbase material around the conduit after placing it in the chase. This proved time consuming, however and problems arose in attaining compaction equal to the unexcavated part of the subbase. To overcome the problem, a P.C.C. slurry was poured around the conduit, encapsulating it in the chase and preventing any voids beneath it. The original plan was for the steel conduit to be bent to connect with the light base hubs. But this was found impractical and a flexible, waterproof coupling solved the problem of making the connection. It also eliminated the stresses tending to move the jig after making the connection and before the concrete anchor had time to set. The concrete anchor was allowed to set securely before the setting jig was removed. The jig was constructed of steel angles 3 x 3 x 3/8 in. and a steel plate 1/4-in. thick from which to suspend the light base. The jig was supported on one end by an adjacent, previously placed lane and on the other end by two adjustable steel-pipe legs attached to the jig.

Sea-Tac Airport at Seattle, Washington was constructed at about the same time as the Los Angeles International Airport. Sea-Tac cast the runway centerline, touchdown zone, high-speed turn-off and taxiway centerline lights monolithically in P.C.C. Pavement. The method used was similar to that used at Los Angeles, except that the jigs were supported by four adjustable legs because the light bases were positioned before any lanes were paved. This setting of jigs "in space" was accomplished by careful surveying for elevation, location and azimuth.

These projects were undertaken in spite of some notable earlier failures. One difficulty was anchoring the base. Since a base 12-in. in diameter and 24 in. deep has a flotation of about 90 pounds displacement in wet concrete and since the paving machine exerts tremendous forces, a solidly anchored base is mandatory. To achieve this, 1/3 to 1/2 yard of concrete was cast around the bottom of the base below the concrete pavement slab. This secured the base and prevented movement during paving.

Also in 1969, Hartsfield International Airport in Atlanta, Georgia constructed a complete P.C.C. runway and supporting taxiways with monolithically cast runway centerline, taxiway centerline and high-speed-exit lights. The entire project was completed in only forty days and nights.

The Port Authority of New York and New Jersey successfully installed an integrated conduit and inset light system in asphaltic flexible pavement at JFK International Airport in 1970. This installation was followed by extensive installations shortly afterward at Newark and LaGuardia Airports in both rigid and flexible pavement.

In 1976 Delaney Debutts of the Airport District Office in Northern Virginia formalized the method of installing inset lighting in existing pavement at Byrd Field in Richmond, VA. following a successful installation designed by Calocerinos-Spina at Syracuse, N.Y. This method is now used in all kinds of paving.

In years since then, most commercial and military airports worldwide have been constructed with conduit and inset lights monolithically set in rigid pavement or integrated into flexible pavements. Dallas-Fort Worth, Jeddah and Singapore are examples of entirely new installations. Examples of facilities converted to in-set and conduit systems are airports at Miami, Portland (Oregon), Washington National, Philadelphia, San Francisco and Oakland, to name a few.

Systems have been installed in all types of construction besides new pavements for instance, flexible overlay of old flexible pavement at Buffalo Airport and P.C.C. overlay of rigid pavement at Milwaukee, in existing flexible pavement at Syracuse and in existing rigid pavement in Rochester, New York. Many installations have been completed under tight schedules and with only minimal interruption of flight operations.

The space-shuttle runway built by NASA at Kennedy Space Center at Cape Canaveral, Florida, in 1975, is a prime example of the combination of skills that contribute to modern installation methods. This runway reveals the effectiveness of an integrated conduit system developed by sound engineering experience, trial and error and cooperation between Civil, Electrical and Illuminating Engineers, as well as participating contractors, operators and regulatory bodies. Through such coordinating of energies, installations have been made in P.C.C. pavement monolithically, using either slipform or standard forming methods. Light bases and conduits have been successfully placed in post-tensioned and pre-stressed. In addition, methods have been devised to utilize new flexible materials and surfaces successfully.

## Various Lights and Their Functions

All of the inset lights mentioned in Table A (on page 16) have specific uses and all use different colors to signify their purpose. The colors are obtained by using absorption filters or lenses. The emissivity of each color varies. This highest value is white (100%), followed by yellow or amber (55%), red (23%), green (21 %) and blue (3%). Using dichroic filters can increase these values for certain colors. White lights are used for signals that have the longest range, such as the runway centerline, runway edge, touchdown zone and approach lights. Taxiway centerline, high-speed-exit and threshold lights are all green. Taxiway-edge lights are blue. The universal codes – red for "danger-do not go" and yellow for "caution" are followed.

Threshold-end lights facing upwind signal that the end of usable runway is approaching. Yellow hold-bars warn of impending intersections. In the United States, red hold-bars are not used unless the red can be switched to green or off. Variations exist such as using yellow at the

intersection of taxiway centerlines. Helicopter pads and apron boundaries are sometimes marked by yellow lights. Turn-offs from runways onto taxiways are usually designated by a double blue edgelight, but an amber light at this location is sometimes used. Dead ends and forbidden entry are always shown in red. (Note: In these pages, yellow and amber are used interchangeably.)

At times, a secondary color accompanies the regular color to convey a special message. For example, runway centerline lights set 2000 feet before the runway's end are alternate red and white and then all red for the last 1000 feet. Similarly, edge lights are amber for the last 2000 feet of the runway, signifying to pilots that usable runway is running short. Approach lights use bars of red lights to signal the closeness of the threshold in Category II and III configurations. Flashing lights (sometimes called "wig wag" lights) are seldom used, but when they are, they alert an aircraft operator to a special condition. These are usually amber and should not be confused with sequenced, white, high-intensity discharge lights used on approach and runway-end identifier lights (REILS). The latter are sometimes installed as inset fixtures if the threshold is displaced.

Lights can be unidirectional, bi-directional and omnidirectional. Touchdown-zone lights are always unidirectional, as are approach lights. However, in some countries and some smaller General Aviation airfields, low-intensity and/or medium-intensity omni-directional approach lights are employed for VFR use. European airports switch between high and low intensities, using a single fixture that houses lamps of both intensities. The omnidirectional lights provide better circling guidance. Hold lights and high-speed-exit lights are usually unidirectional. Most taxiway centerline lights and runway centerline lights are bi-directional. Taxiway intersection lights (and sometimes inset taxiway edge lights) are omnidirectional. Some lights are not only bi-directional, but they also include different colors for each direction. An example is threshold lights, which are green downwind and red facing the runway.

TABLE A

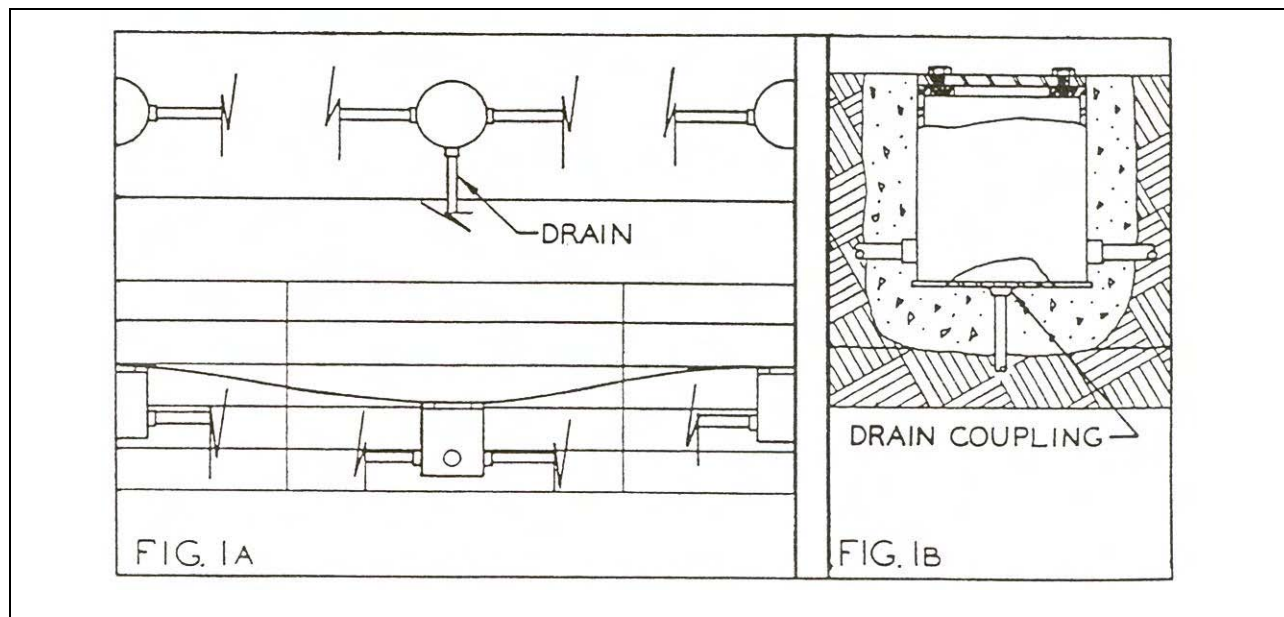
Type	Diameter	Candela
Runway Centerline	12 in.	5000 cd. White
Touchdown Zone	12 in.	5000 cd. White
Taxiway Centerline	10 in. or 12 in.	50-200 cd. Green
Hold Bar	10 in. or 12 in.	50-200 cd. Yellow
Inset Threshold	12 in. or 17 in.	4000 cd. Green
Inset Approach	12 in. or 17 in.	5000 cd. White
Threshold and Hi-Intensity Approach	22 in.	10,000 cd. White
Inset Edge	10 in. or 12 in.	5000-10,000 cd. White
High-Speed Exit	10 in. or 12 in.	50-200 cd. Green



## Problems Posed By Water and Moisture

The truism that water and electricity don't mix holds for inset lighting. Since airport pavement is subject to many sources of moisture, the developers of monolithic systems needed to prevent water and water vapor from making contact with the electrical conductors, contacts and connections. In addition, the lamps used in the fixtures may be damaged by water that touches their hot surfaces. Early attempts to seal water from the light bases and lights employed flat gaskets and "o" rings. These attempts succeeded only partially because moisture in the form of condensed water vapor – which is almost always present in the air – quickly found its way into the light fixture through the conductors, or through small apertures in the seal of the lenses, which caused corrosion of the light's contact fittings.

Some gradual advances were made in controlling moisture about 1965, when manufacturers of inset lights developed seals that prevented moisture from entering the light fixture. Waterproof connectors made connections of the lights and transformers possible without fear of electrical shorting to ground. Although these developments made inset lights more dependable, water within the light bases still created problems. Leakage is especially undesirable in colder climates because of damage done when water freezes, forms into ice and then expands. Experimentation showed that inserting a small block of polyurethane foam prevented damage done to the light fixtures by the expanding ice. Earlier moderately successful attempts to keep water out of bases utilized "o" ring seals between the light fixture and the base. Still, poor maintenance of the "o" ring seals, dirt in the "o" ring grooves and loosening of the holddown bolts allowed water to enter. It could also enter through the conduit system.



Systems using devices to seal out water are known as "dry systems" and are still used in areas with high water tables. About 1975, installations known as "wet systems" were developed. These systems negate the entrance of water by draining the bases through conduit stubs in the subbase. The stubs are located at low spots and allow water to drain to lower elevations at the sides of the pavement. (Figure 1A, above) Another common "wet system" merely drains the light base with a pipe passed through the bottom of the base down into the subbase or a French drain.

This method depends on the percolation of the subsoil. Care must be taken to assure that fines in the subbase are not washed out to form voids, which can weaken support of the light and of the pavement (Figure 1B, on page 17).

### **Other Points of Concern**

Inset lights and the light bases that support them, must be as strong and durable as the pavement of which they are a part. A variety of stresses affect both the pavement and the lights: stresses imposed by dynamic impact; by static, torsional and hydraulic loads; by temperature differentials; and by abrasion and corrosion. Although designing the lights and bases to resist these stresses is fairly simple, periodic inspection and maintenance are still critical in preventing failure or diminished performance. Some soils are more corrosive than seawater. An overall coating of coal tar emulsion properly used and installed will give protection in those kinds of soils.

The bases exist in a corrosive environment. Like any other steel structures, they must be inspected and maintained. The stainless steel bolts that hold the light to the base are subjected to many stresses, not the least of which is the torque tangentially applied by the impact of aircraft wheels or by the twisting action produced by a heavy aircraft's locked wheel during a turn. Loose bolts are an unwanted danger since they are easily sheared or lost, which increases the chance of losing the light fixture and thus creating a hazard to the operation of the airport. In 1975, special locking devices were introduced to lessen the chance of bolts loosening from vibration and shock. But maintenance and periodic inspection are still needed to keep a system's performance at its best.

### **Planning and Designing the System**

Experience shows that there is no standard way to build an airport. Each project includes its own individual variables. Some of these are:

- The type of paving material to use
- Anticipated loads and traffic
- The kind of subsoil
- The kind of subbase to use
- The need for special treatment of the subsoil
- Water conditions at the site
- Other environmental conditions
- The need for concurrent operations during construction
- Funds available

Only the consultant familiar with all the variables of a given airport can properly design the project. Once the specific design is produce appropriate methods can be followed to successfully install the in-pavement lighting system.

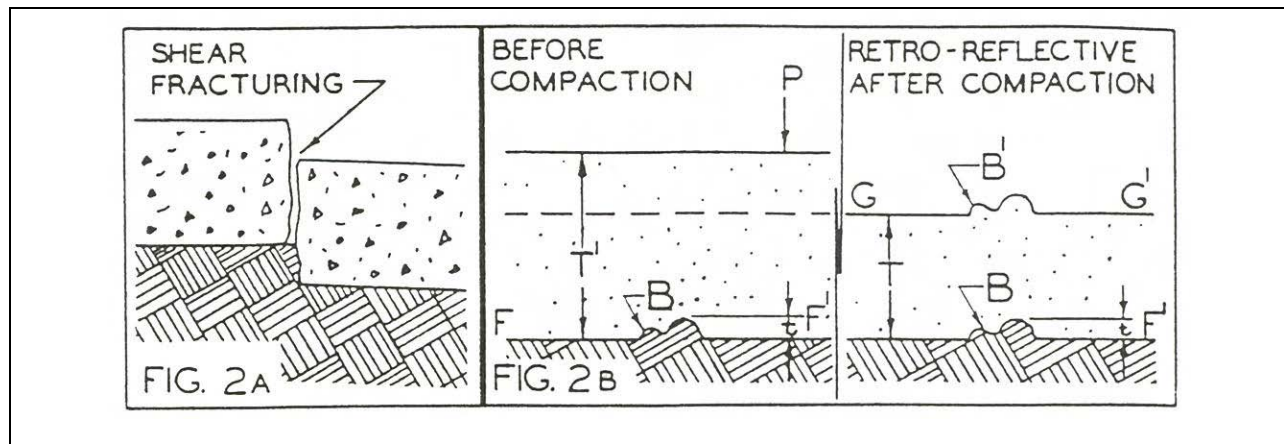
If the designer specifies methods and techniques that have been learned through experience and if the constructor follows the designer's specifications, the odds are that the installation will

be a success. Before starting, carefully investigate any deviation from established methods and equipment. An alternate method may indeed work. It may even produce a better result or simplify the task at hand.

However, the chances are great that the alternate method is no better than the methods now practiced and it may be vastly inferior. Most "new" ideas have been tried before and found wanting in unforeseen ways. It is most important that the designer and operator protect the "interface". Proposals from manufacturers to provide equipment that is non-standard in shape, configuration, etc., should be carefully evaluated as to any claimed improvement in performance, since once such a system is installed, the system is "owned" by the supplier and no replacement is possible without great cost. If the improvement is valid, the chances are that it could be made to meet the interface. In all cases if such innovations are warranted, the regulatory bodies such as the F.A.A. and I.C.A.O. will incorporate them in revised specifications and recommended practices.

### Paving Materials and Techniques

The cement most commonly used is Portland Cement. This is mixed with fine and coarse aggregate and with water. Sometimes, the mixture may include additives such as antifreeze, air-entrainment resins and retarding agents. The real strength of P.C.C. comes from the aggregate, which in turn is held in a matrix of cement. Other types of cements offer special properties, such as reduced time required to reach a usable compressive strength. These are called high early-strength cements. When time is crucial, the fastest of this Magnesium Phosphate Cement, is an alternative to lengthy shutdown time. Calcium Aluminate Cement is another high early-strength mixture, but it is slower in reaching the desired strength. Cost is a factor, too, since the ratio of cost is roughly 16:2:1 (respectively) for, Magnesium Phosphate, Calcium Aluminate and Portland Cement. Setting time for 2000 psi (again respectively) is 45 minutes, 4 hours and 5 to 7 days.



The cement sets into a crystalline solid as the result of a chemical reaction (called hydration) between the cement and water. The noticeable physical change is a hardening of the mixture from a viscous, plastic semi-fluid into a hard material. The ratio of cement to the total mix and to

the volume of water used affects the mixture's strength. Some volume change takes place between the mixture's liquid and solid state. Too much water weakens the strength of the concrete; too little prevents complete hydration, which also lowers the strength. The concrete's strength is controlled by the percentage of water to cement, the percentage of cement to aggregate and the kind of aggregate used. If the subbase that supports the slab fails, the concrete – a rigid, non-flexible material will break in shear, as shown in Figure 2A, on page 19, with the resulting sharp distortion of the section.

Asphalt cement concrete is made of a mixture of asphalt and graded aggregate. The aggregate is held in a matrix of the bituminous asphalt. To achieve a strong bond, mechanical pressure, termed "compactive effort," must be applied to the mixture, usually at a relatively high temperature to provide plasticity. Pressure is applied by heavy rollers. The change in density is considerable. This is because the density is affected by thickness, aggregate size, temperature of the mix and weight and action of the roller.

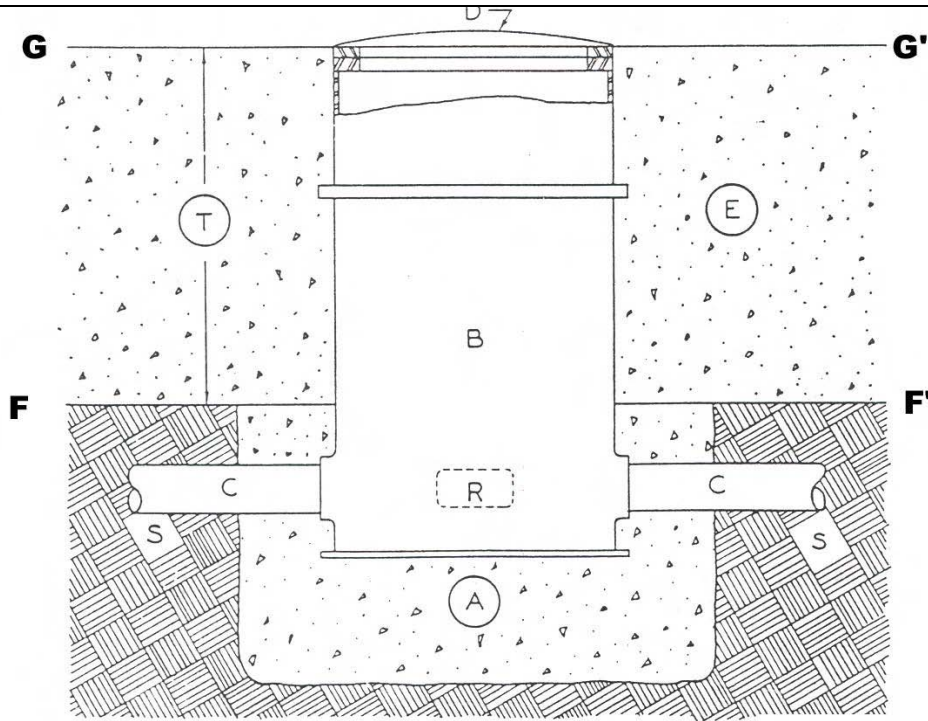
Figure 2B, above, illustrates a characteristic of flexible paving known as the "shadow effect." The surface F-F' is the top of the sub-base. A thickness (T) of asphalt paving is to be laid on, using thickness of (t') of uncompacted material. If some foreign object such as (B) is present on the surface F-F' when the compactive effort (P) is applied, the surface G-G' will appear as shown sometime after the paving is completed. This occurs because the stresses set up in the paving are functions of (and vary with) the pressure per cross-sectional depth of the material being compressed. This is an inverse relationship. Thus, the thinner the section T-t' is (pressure remaining constant), the more stress there will be in the material. When (P) is removed, these stresses tend to equalize, bringing about the surface contour of (B') as the stresses approach equilibrium.

Clearly, differences in placement affect the planning of monolithic, in-pavement light systems because flexible pavement and rigid pavement require different installation measures.

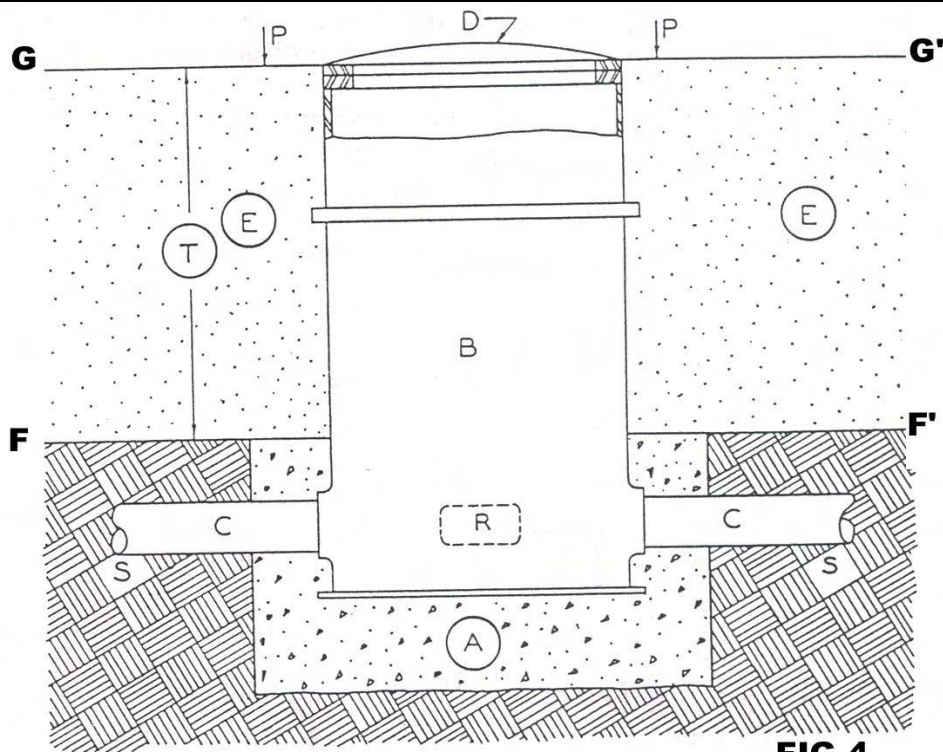
Consider the typical rigid-paving installation shown in Figure 3, on page 21.

The light base (B) is set in an anchor of Portland Cement Concrete (A) at the proper light-beam azimuth and with the elevation of the light (D) flush with (or level at) the planned pavement elevation (G-G'). The anchor is poured level with the top of the subbase (F-F'). Electrical energy from an isolating transformer (R) is delivered to the light fixture (D) by cables in conduits (C) placed in the subbase (S). Once light base (B) is positioned and held, placing of P.C.C. (E) to the desired elevation (G-G') insures that the installation achieves the correct dimensions.

Now consider a flexible pavement installation in Figure 4 on page 21. Here, we have exactly the same picture shown in Figure 3, on page 21, except that (E) is now asphalt cement concrete instead of P.C.C.



**FIG 3**



**FIG 4**

If we follow the same procedure as in Figure 3, on page 21, everything goes well until we set the concrete anchor (A) and prepare to place (E). However, to get the asphalt concrete to the proper strength through compactive effort, the initial thickness must be somewhat more than (T) to allow for compression. And that is not all: to assure homogeneous density throughout (E), we must also apply pressure in the area of (P) as well as all over the surface G-G'.

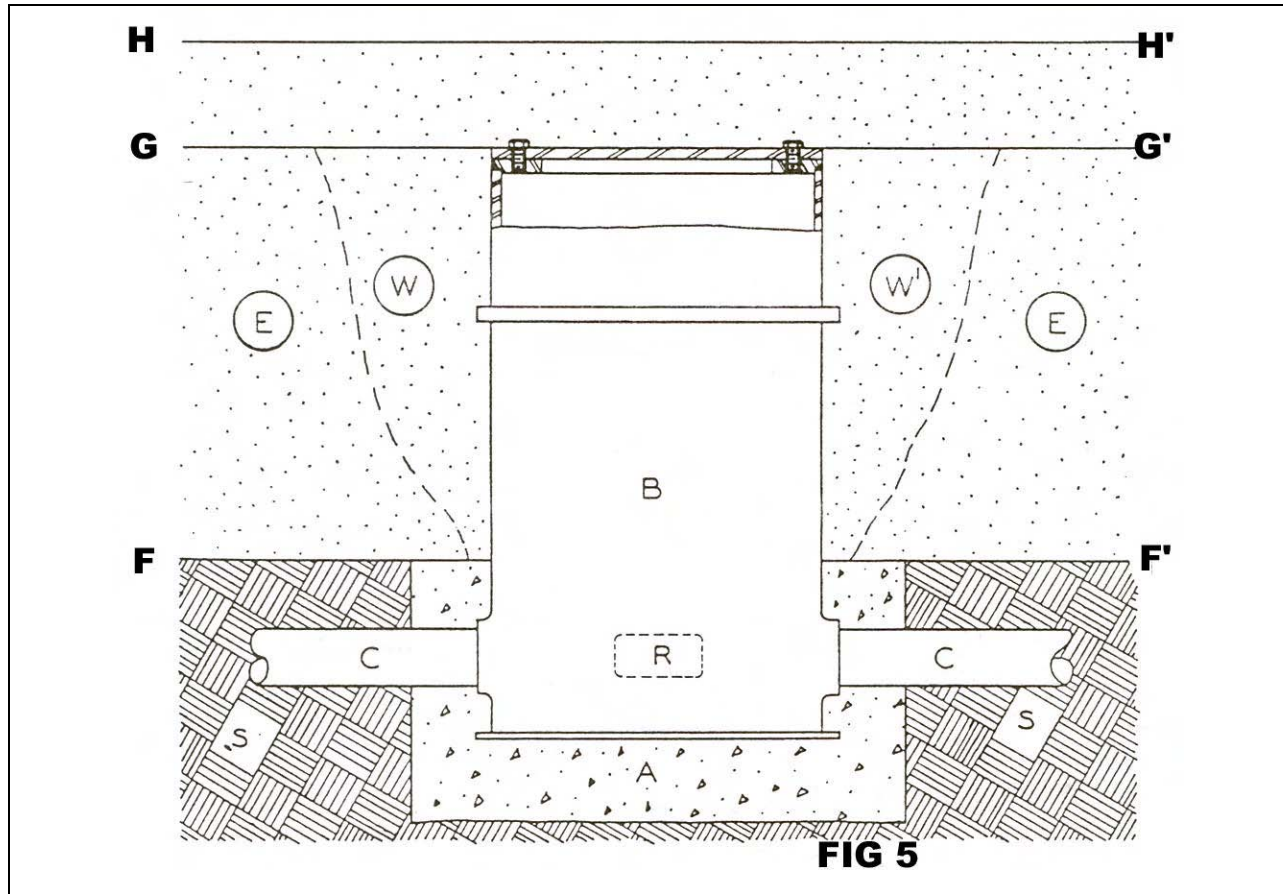
So let's go back to the stage of preparation up to line F-F' (Figure 5, below). Knowing that we must lay materials of section (E) up to elevation H-H', it is obvious that our light base will be covered up and the light base will be impacted by the roller while the asphalt is being compressed. The light base might support the weight of the roller and if it can withstand the roller's impact, it will prevent proper compacting of the asphalt. This could cause a density lower than that needed to meet the specified strength of pavement in the volume of material in W-W'. The pavement would deteriorate quickly once it went into use. Hand tamping cannot produce the necessary density that a heavy roller can produce. If the light base was impacted and if movement took place, then the azimuth, elevation and slope of the light would certainly not be in tolerance. For this reason, installing inset lights in rigid as opposed to flexible pavements dictates different methods, which are explained in later sections covering specific installation conditions.

Portland Cement Concrete (P.C.C.) is a stable material not significantly affected by normal ambient temperatures and it resists abrasion well. Water and fuel residues have little effect on the material's stability. Nevertheless, impact from a sharp, heavy object (such as the steel blade of a snowplow, or a wheel with a flat tire) can break the surface and cause spalling – a loosening of the aggregate. This is serious on airport pavement because loose materials can be drawn into jet engines.

Different problems occur with asphalt pavements. While it is a solid at normal temperatures, asphalt approaches the properties of a liquid as its ambient temperature rises. At prolonged high temperatures, asphalt acts much like a liquid and its shear strength diminishes as the temperature rises. However, as the pavement ages, the material becomes less plastic. Glue-in inset lights placed in asphalt pavements have been known to drift, like a saucer floating on water. This movement is slow and leaves no wake, yet under high ambient temperatures, waves apparently can be produced in bituminous pavement by the shock of impacting heavy aircraft and by the stresses caused by sharp turns and hard braking. This action could affect glued-in light fixtures in particular, but inset bases supported by concrete anchors in the subbase prevent the problem from occurring.

Asphalt pavements have given good service, but some characteristics of bituplastic materials must be considered before installing an inset light system in asphalt pavement. At high ambient temperatures, it can become thinner under the compression of heavy traffic. A small change in thickness, accompanied by a beneficial increase in density will not affect its ability to bear loads – as long as its base is sufficiently strong. However, part of the light base is encased in P.C.C. separate from the asphalt and is also supported by the subbase, so any slumping of the pavement around the top of the light fixture will produce a difference of elevation. The resulting uneven pavement will produce forces that act on the nose wheel of an aircraft rolling over it. Because an aircraft moves at relatively constant speed in the early stages of rollout, it can be subjected to

simple harmonic motion which can make control of the aircraft difficult. This very condition occurred when the installation at Sacramento was exposed to warm weather. The solution involved removing some concrete near the top of the encasement around the light fixture and then covering it with compacted asphalt to match the surrounding pavement. A minimum thickness of 3 in. of asphalt pavement over the concrete seems to distribute the forces evenly enough to prevent concrete breakage and insure smooth rollover.



Compared to asphalt, P.C.C. adheres better to epoxies and certain catalysts used in the adhesives were found to react with the asphalt and changed it to an oily liquid, causing it to lose its bond with the aggregate. Adhesives compatible with bituplastic materials should always be specified for use in asphalt pavements.





# **Monolithic Installation of Light Bases in New P.C.C. Pavement**

**(Using an Existing Elevation as Reference)**

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Laying the Conduit  
Marking Reference Points  
Placing the Jigs and the Light Bases  
Connecting the Light Bases  
Anchoring the Light Base  
Procedures during Paving  
Making the Fixture Flush  
Completing the Installation

For this type of installation, whenever possible, lanes having few or no lights, should be paved before those having many. This provides reference for the elevation of lights to be installed.

**Note:** The example (Figure 6 A&B, on page 27) is for a jig measuring six by two feet. If a jig, of different size is used, make adjustments accordingly. See Figure 6B on page 27, for the construction of a jig. (The terms "jig" and "setting fixture" are used interchangeably here.)

### **Laying the Conduit**

Carefully dig a chase into the compacted base between the light bases, as shown on the construction drawings and as located by the surveyor. Make the chase 6-in. wide and 3 in. deeper than the conduit connection to the light base. Lay conduit in the chase and support it so that the conduit's center is 3 in. from the bottom of the chase. Carefully remove all excavated material. Fill the chase with P.C.C. at the same time as the light-base anchors are poured. Take care to eliminate voids or loose material beneath the conduit.

### **Marking Reference Points**

Lights may be positioned either parallel to the centerline of the pavement or at an angle to it. A parallel pattern is for centerline lights that run in a straight line; other patterns are for lights on a curve, or for hold bars perpendicular to the centerline.

The surveyor will mark a reference point on the existing adjacent pavement opposite the point that the inset light will occupy. (Figure 7, on page 28).

For lights with light beams parallel to the centerline the distance from the edge will be set by the dimension measured from the end of the jig to the center point of its holding plate. The surveyor will also mark points 2 feet on each side of the reference point on a line parallel to the light beam. For example, if the light beam will be parallel with the centerline, a line through the three points would be parallel to the pavement edge.

For lights with light beams at an angle to the centerline, the surveyor will mark points 2 feet on each side of the reference point on a line perpendicular to the light beam. A line through the three points would be perpendicular to the light beam and would be at an angle to the centerline and pavement edge.

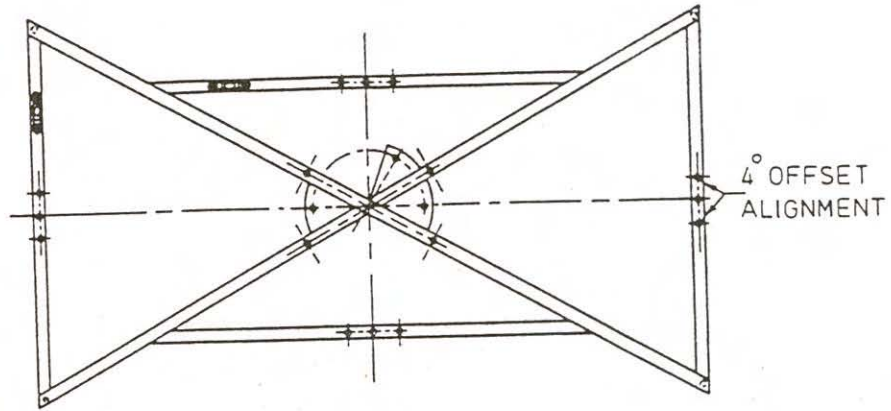
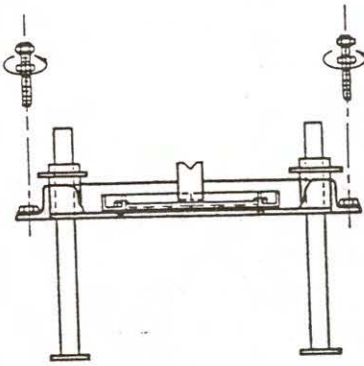


FIG. 6A



END VIEW

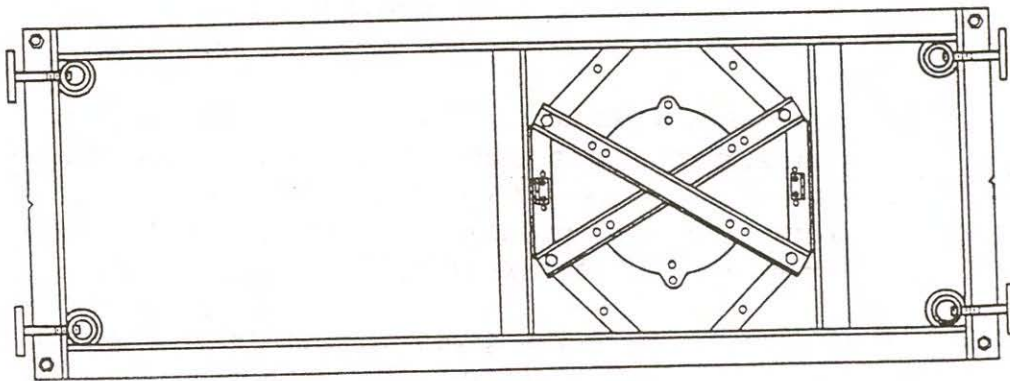


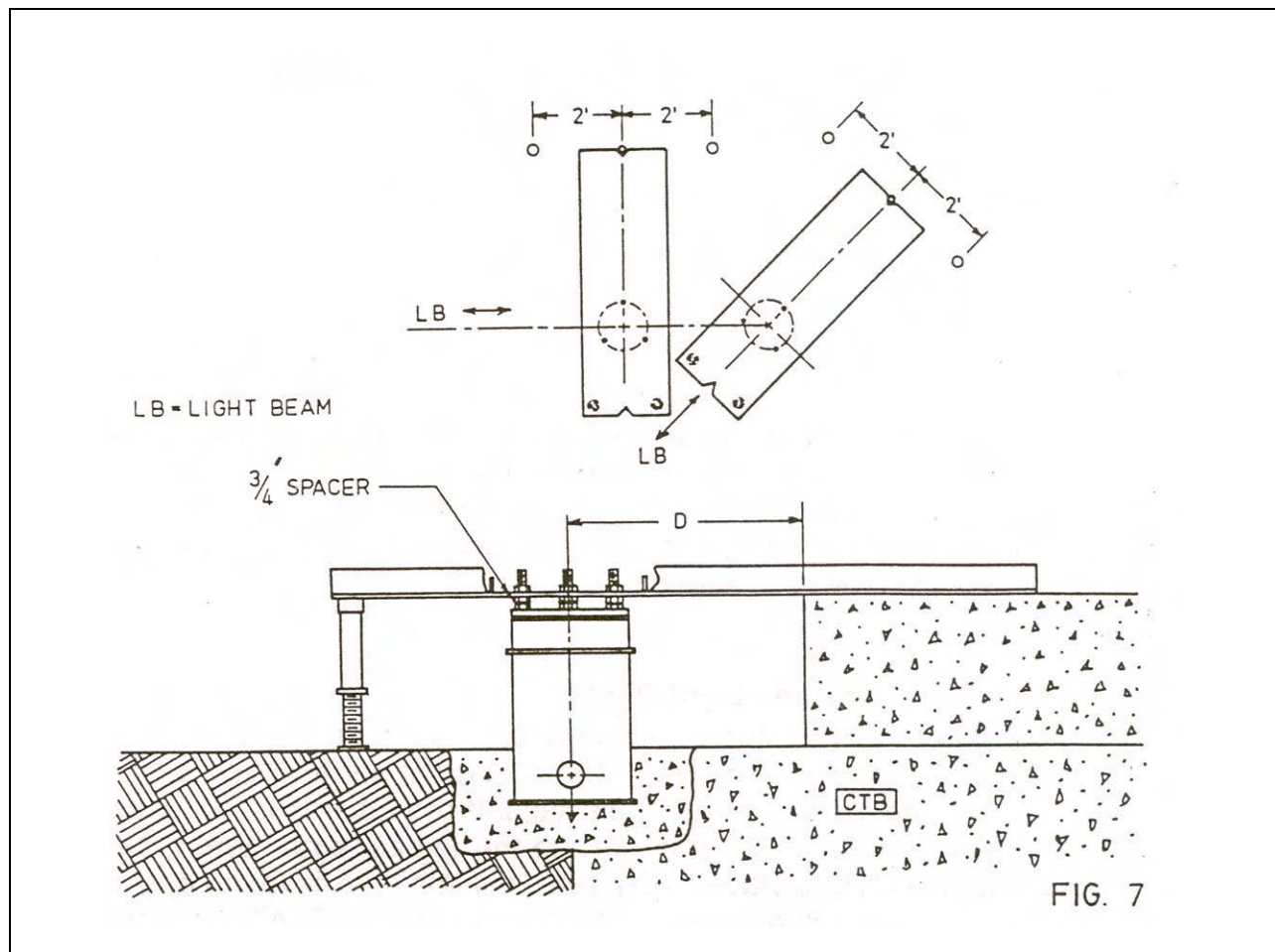
FIG. 6B

## Placing the Jigs and the Light Bases

The light base is centered precisely on the light's location. At this point, make an excavation about 3 feet in diameter and at least 6 in. deeper than the bottom of the light base. If the base is CTB (cement-treated base), make the opening in the treated base no more than 48 hours after the CTB is placed. Any delay will make excavating difficult. Take care not to crack or damage the surrounding CTB. A 36-in. core is the usual way to make the opening.

Place the jig so that its square end lines up with the line through the displaced center point of the light on the adjacent lane. Place the center mark on the end of the jig on the displaced center point. The center of the jig's attachment plate is now directly over the center point of the light. If the jig is accurate, the azimuth of the light is now set. The surveyor can check this setting by sighting a transit through the gun-sight on each side of the jig to check the azimuth setting the jig makes.

Most centerline lights are displaced two feet off the true centerline, so the square end of the jig will be positioned where the center-point line is marked. If the centerline of the light is something other than two feet off the edge, an adjustment is made to allow for this by locating the marks on the adjacent lane the proper distance from the edge.



If the light beam is at an angle to the centerline, the line through the points will not be parallel to the edge. Though centerline lights are always within reach of the jig, some lights, distant from the reference edge may be out of the jig's reach. The jig may consequently lack room to lie completely on the adjacent edge. Examples are radially located high-speed turn-off lights or touchdown-zone lights that may be far from the paved edge. In cases like these, the light bases must be set by the "in-space" method (See steps under Monolithic "In-Space" Installation of Light Bases in New P.C.C. Pavement). Lights parallel to the centerline are the most common, however.

### **Connecting the Light Bases**

If the base has a threaded hub, use a nipple and coupling to make the connection to the light base inside the excavated hole. Steel and other rigid conduits require a waterproof, flexible connection. Usually, one flexible coupling will suffice for each two-hubbed light base.

If the light base has a grommet opening, insert the conduit into the grommet to make the connection. The depth of penetration into the light base depends on the thermal coefficient of expansion of the material the conduit is made of. Steel conduits should enter the light base about 3/4 in. and PVC conduits should enter about 1/4 in.

Light bases may have numerous entrances and entrance locations, depending on branches in the conduit and drain systems. Make all connections now. When planning the installation, remember to place all conduit branches in concrete-filled chases in the subbase of lanes scheduled for paving before lanes with light bases.

If the light will provide ground guidance, adjust the two legs of the jig that rest on the compacted subbase so that the jig slopes at the drainage angle of the lane to be paved. Do this by using small spirit-levels attached to the top of a side and end member of the jig. These should be shimmed the proper amount to read level when the jig rests at the desired slope. Both sides of the jig should be in contact with the adjacent pavement to set the slope front-to-back.

The light base assembly consists of a plywood cover 5/8 in. thick and a steel mud plate 1/8 in. thick. The light base assembly must be set 3/4 in. below the holding plate. Do this by suspending the base on long bolts, or by using a spacer built into the jig. (Figure 7, on page 28).

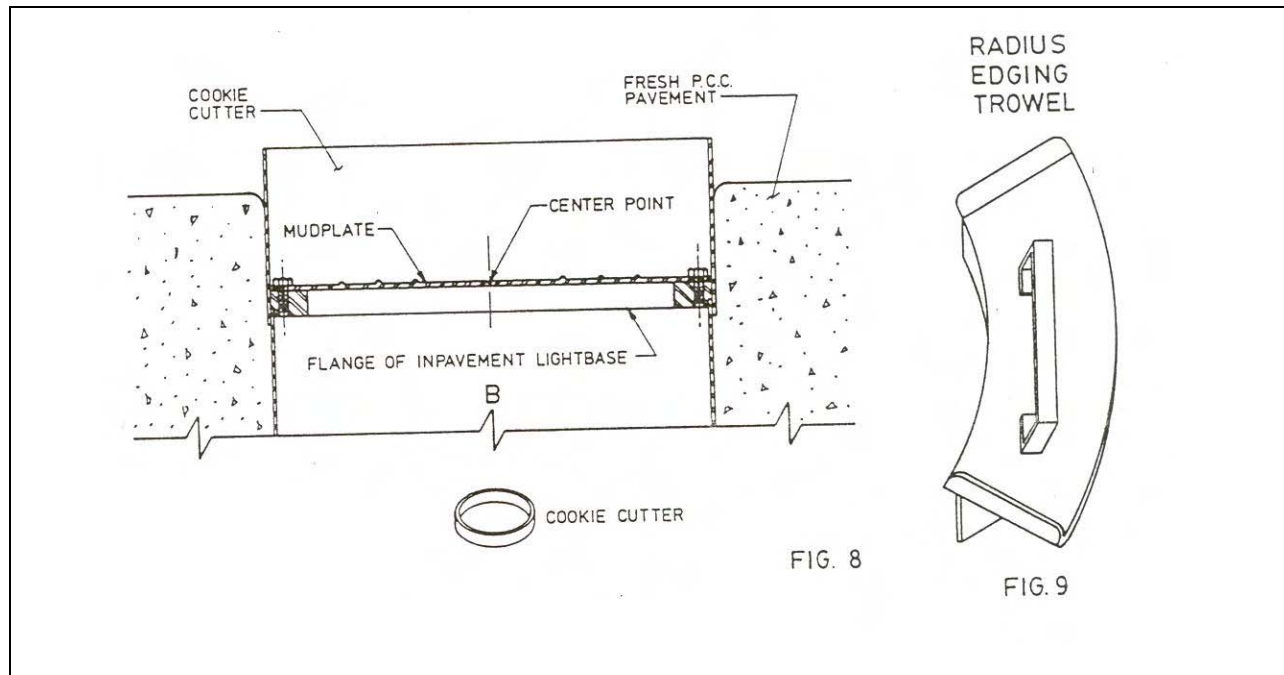
### **Anchoring the Light Base**

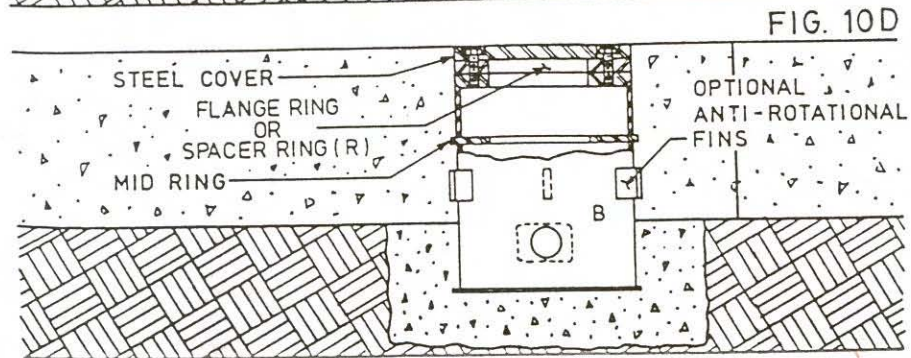
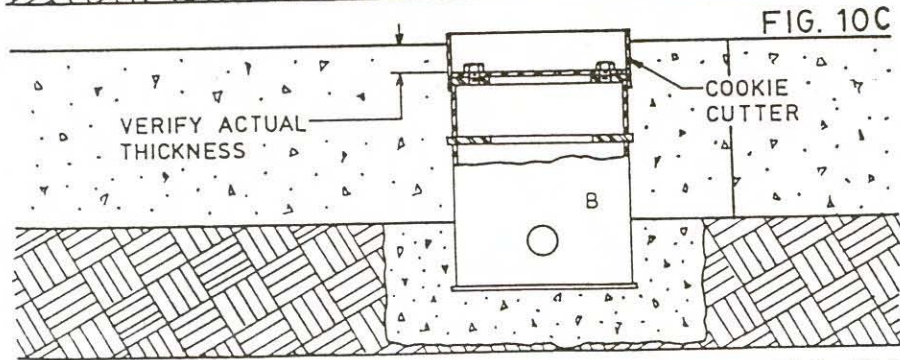
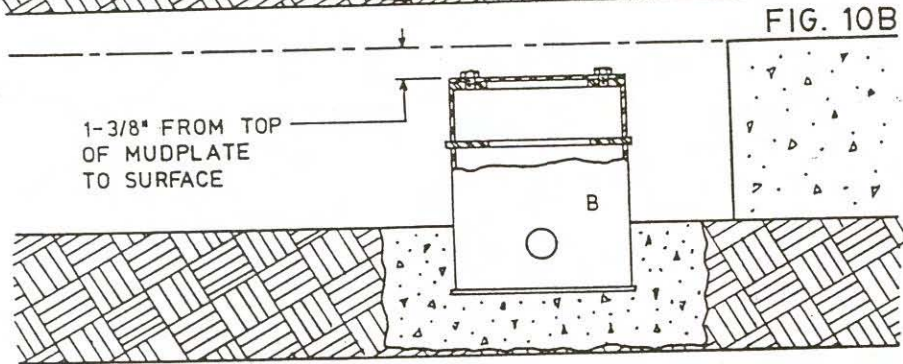
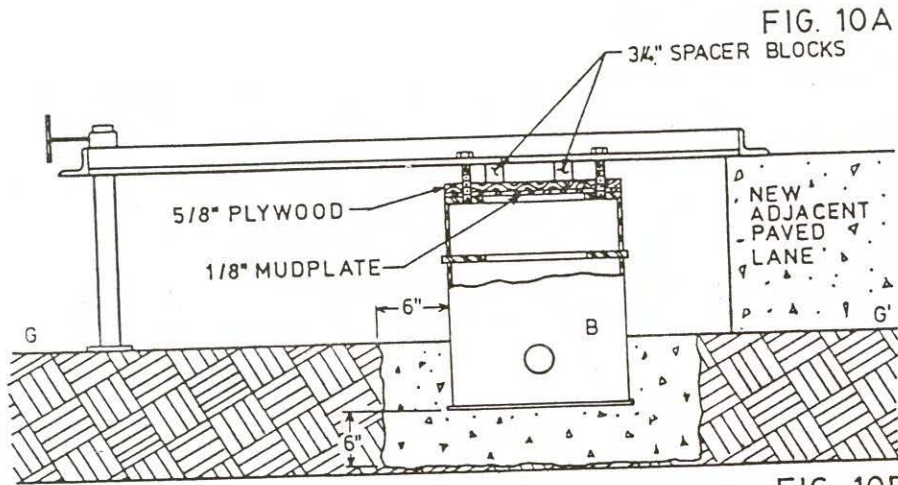
When the jig and base assembly has been checked for alignment and the light base is set at the proper azimuth, elevation and slope, then weight the jig with sandbags to prevent movement. Pour a minimum of 1/3 yard of P.C.C. around the bottom of the light base as an anchor. Be careful not to intrude into the space reserved for the future pavement. It is good practice to recheck the azimuth, elevation and slope before the concrete anchor has set. Allow the base anchor to cure until the concrete reaches adequate strength. The jig can be removed in 24 hours, but protect the base from being hit by moving vehicles and equipment (Figure 10A, on page 31)

## Procedures during Paving

When the light bases are ready to be cast in the pavement, remove the plywood cover and bolt only the mud plate to the light base. (See Figure 10B, on page 31) The paving proceeds normally, with the light base 1-3/8 in. below the surface. During the process, a bridge spanning the paving lane behind the paving train stops at each buried light base. A worker on the bridge directly over the light base inserts a "cookie cutter" (a thin metal hoop slightly larger in diameter than the base and about 5 in. high) around the base and works it down into the wet concrete at least 1 in. below the base's top. (Figure 8, below)

Note: Locating the light base is not difficult: with experience, the worker will recognize the location by its slightly different appearance. If needed for reference, though, the longitudinal location in the pavement can be marked on opposite sides of the lane. The worker on the bridge carefully removes the wet concrete inside the hoop down to the mud plate. He removes the mud plate, cleans the top flange of the light base and makes sure there is no wet concrete on the bottom of the mud plate. He then rebolts it to the light base. If the wet paving outside the cookie cutter has been disturbed, he repairs it, making sure that the concrete outside of the cookie cutter has the same elevation as the paving. He finishes the edge around the cookie cutter with a special curved trowel to provide a radius around the edge of the opening. (Figure 9, below)





Note: Wiping the cookie cutters with a light vegetable oil before inserting them makes their removal later on easier.

Sometimes, plans require that the pavement be laid down in more than one pass. An example is when steel mesh must be inserted in the pavement some distance from the top. This requires a procedure similar to the one described above, except that a two-piece light base is used.

In this procedure, place the bottom section of the base as described above. Also set azimuth and slope. A worker on a bridge that trails the paving train (on its first pass) removes the wet concrete and mud plate from the top of the bottom section. He cleans the top flange of the bottom section and bolts the top section to the bottom-section flange after applying a thin layer of RTV 118 between them. He then attaches the proper mud plate to the top section. The top of the top section assembly is now 1-3/8 in. below the estimated elevation of the second pass. The worker roughly repairs the concrete around the bottom section.

During the second pass (made soon enough to prevent a cold face between passes), a second worker on a bridge following the second paving train completes the operation by performing the procedures described above for a one-piece light base.

### **Making the Fixture Flush**

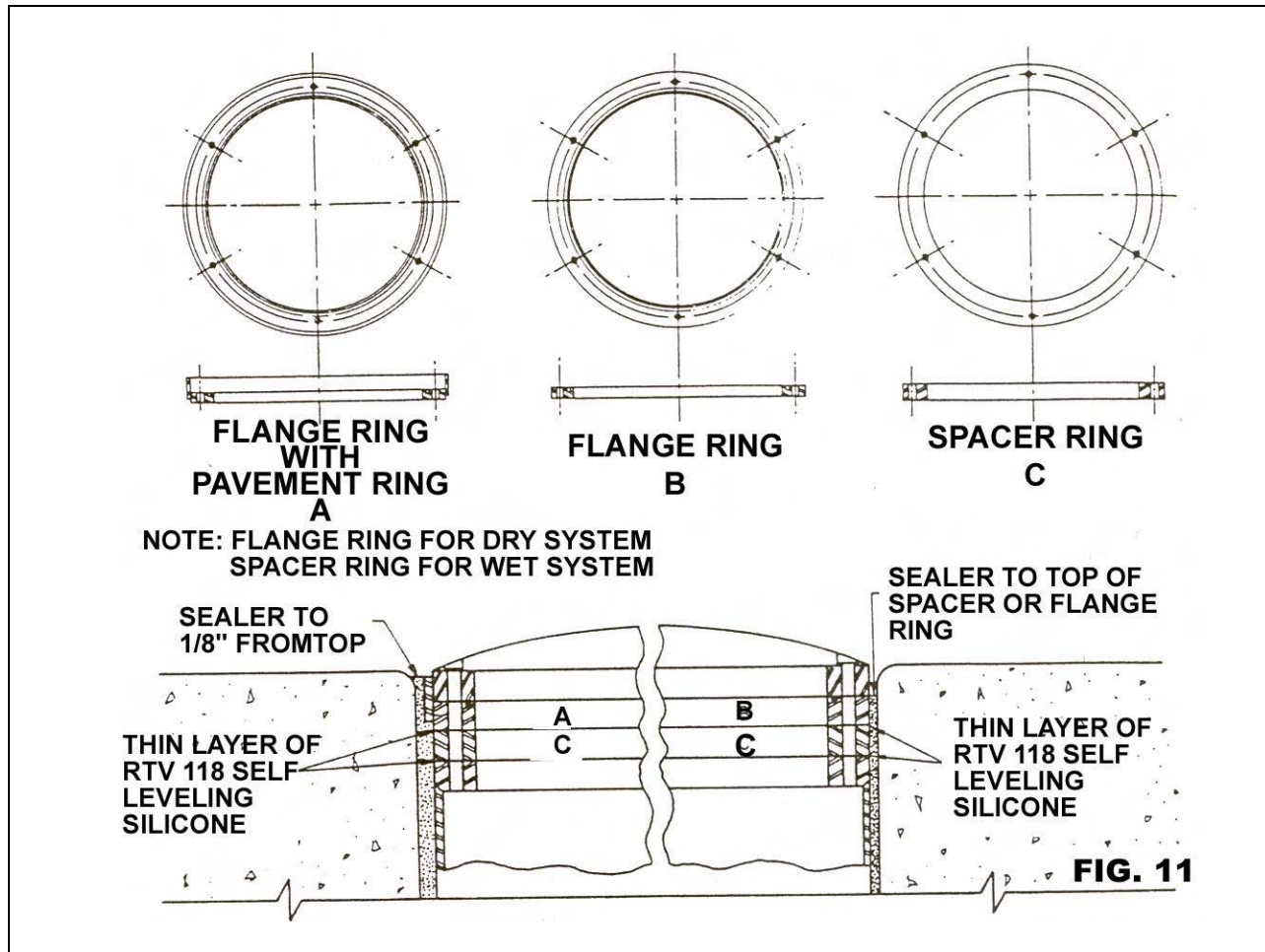
When the concrete has set, remove the cookie cutter and mud plate. The actual depth of the concrete is measured between the top of the paving and the mud plate. If the pavement is the specified thickness, remove the mud plate and insert a spacer ring 3/4-in. thick. This will leave a space the thickness of the light from the surface. (Figure 10C, on page 31) If the pavement is thicker than specified, use a thicker or extra spacer ring to bring the light fixture flush with the surface.

On a "dry system," use a flange ring instead of a spacer ring. If the thickness of the concrete above the light-base flange is more than 1-1/2 in., use a spacer ring of proper thickness together with the flange ring to bring the light flush with the surface. If the thickness of the concrete above the base flange is less than 1-1/2 in., use a thinner flange ring.

The thinnest flange ring possible is 1/4 in. thick. If this is too thick, the paver has missed the thickness by 1/2 in., which usually justifies rejecting the paving. If the pavement is accepted and the installation is a "dry system," see procedures under Remedial Methods. The thinnest spacer ring is 1/16 in. If this is too thick, the pavement is under-thick by 11/16 in. Again, if accepted (hardly possible!), see Remedial Methods.

Spacer rings starting at 1/16 in. and flange rings starting at 1/4 in. can be used in increments of 1/16 in. You can combine spacer rings of different thickness, just as you can combine spacer and flange rings. Nevertheless, avoid using more than three rings if each is less than 3/8 in. thick. Never use more than two rings to make adjustments under 3/8 in.





### Completing the Installation

Attach the light fixture to the light base with stainless steel bolts and anti-rotation lock washers, using a torque recommended by the manufacturer of the light base (usually 180-in. lb.). Provide a thin layer of self-leveling silicone sealer between the spacer or flange ring and the light base flange. (Figure 11, above) You can use the plywood cover supplied with the light base on top of the spacer or flange ring as a temporary cover. If you expect a long delay before the light fixture is installed, use a steel cover equal in dimensions and strength to the light fixture. (Figure 10D, on page 31)



# **Monolithic "In-Space" Installation of Light Bases in New P.C.C. Pavement**

(With no existing elevation as reference)

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Laying the Conduit  
Marking Reference Points  
Placing the Jigs and the Light Bases  
Connecting the Light Bases  
Anchoring the Light Base  
Procedures during Paving  
Making the Fixture Flush  
Completing the Installation

An installation is set "in space" when it has no adjacent lane to use as a reference for elevation and slope (front-to-back) of the light fixture and its base.

### **Staking Center Points**

The surveyor will stake all center points of inset lights and will set elevations for the compacted subbase and the finished pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will stake the center point of the light's location on the centerline of the light beam.

If the light beam will be at an angle to the centerline, the surveyor, will stake the center of the light fixture and will also locate two points 6 feet on each side of the center point, on a line through the center point and perpendicular to the centerline of the light beam.

At each center point, make an excavation about 3 feet in diameter and deep enough to hold a minimum of 1/3 yard of P.C.C. around the bottom of the light base. If the base is CTB (cement treated base), make the opening in the treated base no more than 48 hours after the CTB is placed. Any delay will make excavating difficult. Take care not to crack or damage the surrounding CTB. A 36-in. core is the usual way to make the opening.

### **Laying the Conduit**

When the excavation at the center points of the lights is done, carefully dig a chase into the compacted base that runs between the light bases. Make the chase 6-in. wide and 3 in. deeper than the conduit connection to the light base. Remove all excavated material. Lay conduit in the chase and support it so that the conduit's center is 3 in. from the bottom of the chase. Fill the chase with P.C.C. at the same time that the light-base anchor is poured. Take care to allow no voids or loose material beneath the conduit.

### **Placing the Jigs and Connecting the Light Bases**

The jig (Figure 6B, on page 27) straddles the excavation so that the bottom of the holding plate is at the elevation of the finished pavement and rests on four adjustable legs. (Figure 12L on page 37) For lights with light beams parallel to the centerline, the surveyor can line up the jig(s) by sighting a transit through the gunsights on the sides of the jig so that he can locate the line through the center point of the light. He can then chain the distance between lights as shown on the drawings.

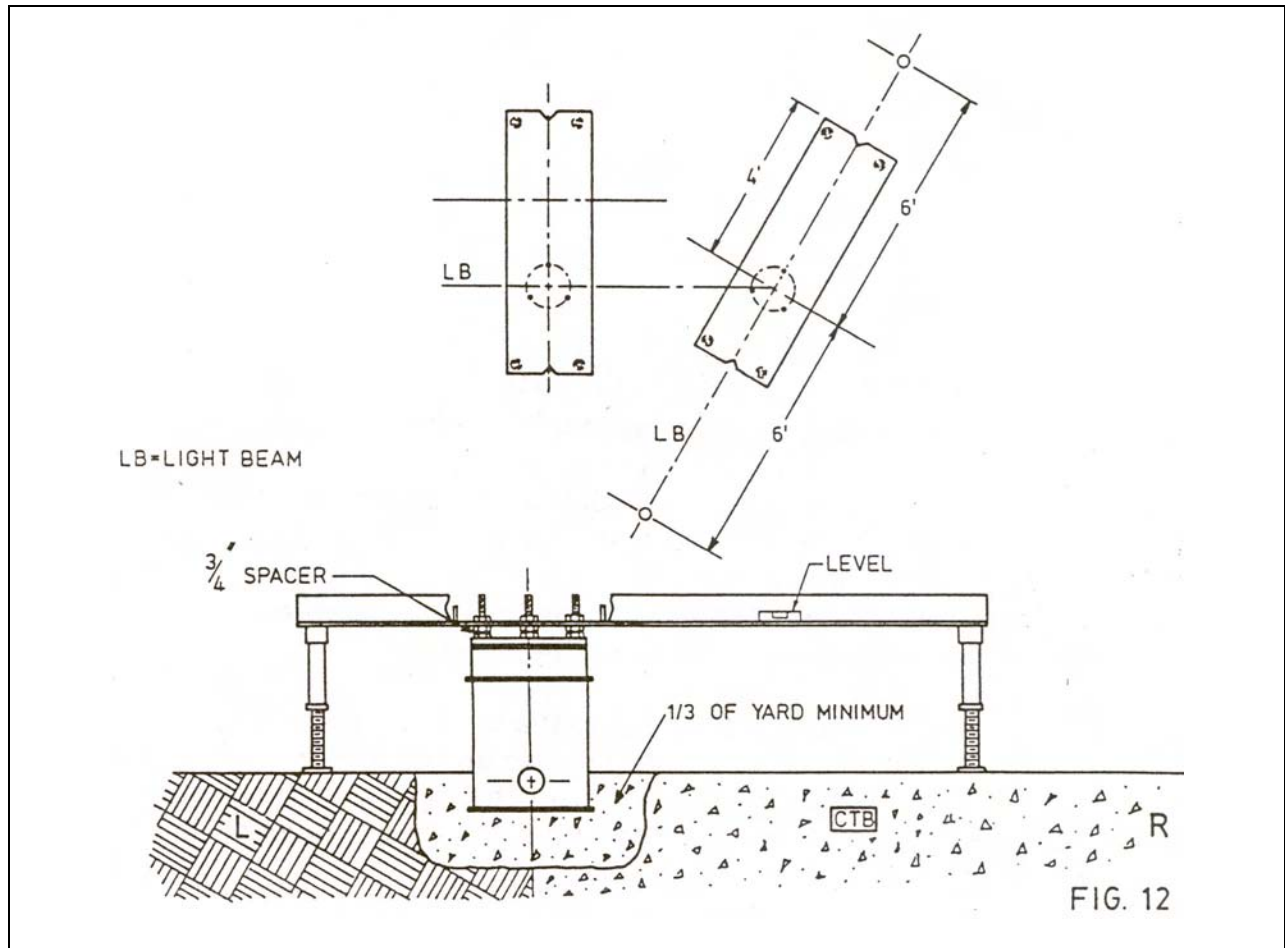
For lights with light beams at an angle to the centerline the surveyor locates the center point through the gun sights on the sides of the jig and sets the light's position by using a wire through the two points perpendicular to the light beam and the gunsights on the ends of the jig

If the light base has a threaded hub, use a nipple and coupling to make the connection to the light base inside the excavated hole. Steel and other rigid-conduits require a waterproof, flexible coupling. Usually, one flexible coupling will suffice for each two-hubbed light base.

If the light base has a grommet opening, insert the conduit into the grommet to make the connection. The depth of penetration into the light base depends on the thermal coefficient of expansion of the material the conduit is made of. Steel conduits should enter the light base about 3/4 in. and PVC conduits should enter about 1-1/4 in.

Light bases may have numerous entrances and entrance locations, depending on branches in the conduit system. Make all connections now. Place all conduit branches shown on the plans including drainage stubs – in concrete-filled chases in the subbase of lanes scheduled for paving before lanes with light bases.

If the light will provide ground guidance, adjust the two legs on the jig's low side to match the drainage slope of the lane to be paved. The surveyor can measure this by using an optical level at each end of the jig, or by using a small spirit-level attached to the jig on its long side and shimmed the proper amount to read level when the jig rests at the desired slope. The surveyor then sets the slope from front to back by reading the elevation of the two sides of the jig next to the gunsights.



If the light will provide airborne guidance, the jig is set level all around. When lights are set level, the amount of the light above the pavement on the pavement's low side should equal the amount that the light is lower than the pavement on the high side. (This is about 1/16 in. for a 12-in. diameter light on a normal drainage slope.)

The light base assembly includes a 5/8-in. plywood cover and 1/8 in. steel mud plate. The light base assembly must be set 3/4 in. below the holding plate. Do this by suspending the base on long bolts, or by using a spacer built into the jig. (Figure 12, on page 37)

### **Anchoring the Light Base**

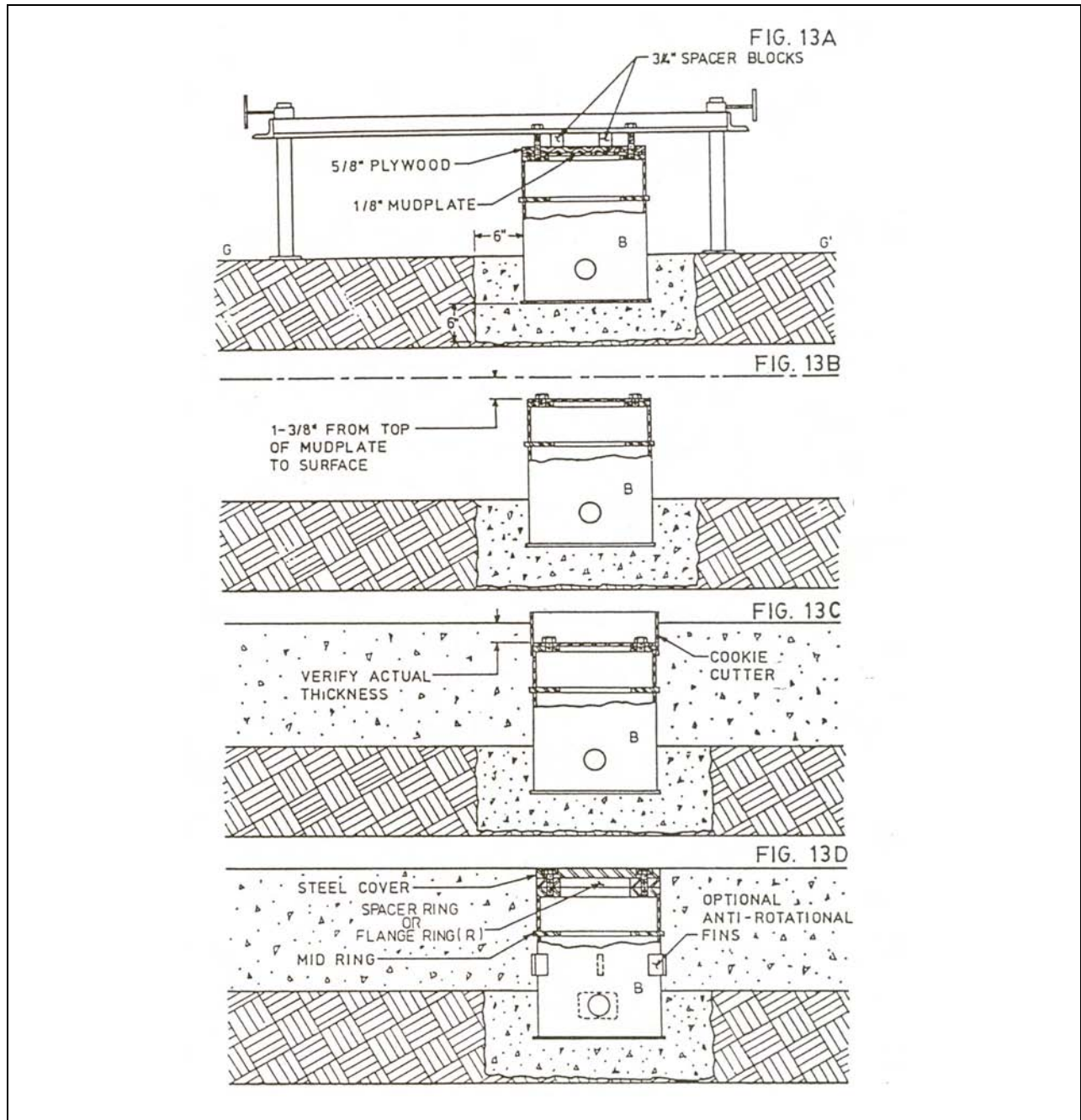
When the jig and base assembly has been checked for alignment and the light base is set at the proper azimuth, elevation and slope, then weight the jig with sandbags to prevent movement. Pour a minimum of 1/3 yard of P.C.C. around the bottom of the light base as an anchor. Take care not to intrude into the space reserved for the pavement. It is good practice to recheck the azimuth, elevation and slope before the concrete anchor has set. Allow the base anchor to cure until the concrete reaches adequate strength. The jigs can be removed in 24 hours. (Figure 13A, on page 39)

### **Procedures during Paving**

When the light bases are ready to be cast in the pavement, remove the plywood cover and bolt only the mud plate to the light base. The paving proceeds normally. A thickness of 1-3/8 in. of wet concrete will cover the light base assembly. (Figure 13C, on page 39) During the process, a bridge spanning the paving lane behind the paving train stops at each buried light base. A worker on the bridge directly over the light base inserts a "cookie cutter" (a thin metal hoop slightly larger in diameter than the base and about 5 in high) around the base and works it down into the wet concrete at least 1 in. below the base's top. (Figure 8, on page 30)

Note: Locating the light base is not difficult: with experience, the worker will recognize the location by its slightly different appearance. If needed for reference, though, the longitudinal location in the pavement can be marked on opposite sides of the lane.

The worker on the bridge carefully removes the wet concrete inside the hoop down to the mud plate. He then removes the mud plate, cleans the top flange of the light base and makes sure there is no wet concrete on the bottom of the mud plate before rebolting it to the light base. If the wet paving outside the cookie cutter has been disturbed, he repairs it, making sure that the concrete outside the cookie cutter is level with the paving. He finishes the edge around the cookie cutter with a special curved trowel (Figure 9, on page 30) to provide a radius around the edge of the opening.



**Note:** Wiping the cookie cutters with a light vegetable oil before inserting them makes their removal later on easier.

Sometimes, plans require that the pavement be laid down in more than one pass. An example is when steel mesh must be inserted in the pavement some distance from the top. This requires a procedure similar to the one described above, except that a two-piece light base is used.

In this procedure, place the bottom section of the base as described above. Also set azimuth and slope. A worker on a bridge that trails the paving train (on its first pass) removes the wet concrete and mud plate from the top of the bottom section. He cleans the top flange of the bot-

tom section and bolts the top section assembly to the bottom section flange after applying a layer of RTV 118 between them. He then attaches the proper mud plate to the top section.

The top of the top section assembly is now 1-3/8 in. below the planned elevation of the second pass. The worker roughly repairs the concrete around the bottom section.

During the second pass (made soon enough to prevent a cold face between the passes), a second worker on a bridge following the second paving train completes the operation by performing the procedures described above for a one-piece light base.

### **Making the Fixture Flush**

When the concrete has set, remove the cookie cutters. The actual depth of the concrete is measured between the top of the paving and the mud plate. If the pavement is the specified thickness, the mud plate is removed and a 3/4-in. thick spacer ring is inserted. This will leave a space equal to the thickness of the light from the surface. If the pavement is thicker than specified, use a thicker or extra spacer ring. If the pavement is thinner than specified, use a thinner spacer ring to bring the light fixture flush with the surface.

On a "dry system" use a flange ring instead of a spacer ring. If the thickness of the concrete above the light base flange is more than 1-1/2 in., use a spacer ring of proper thickness together with the flange ring to bring the light flush with the surface. If the thickness of the concrete above the light base flange is less than 1-1/2 in, use a thinner flange ring. (Figure 13C, on page 39)

The thinnest flange ring possible is 1/4 in. thick. If this is too thick, the paver has missed the thickness by 1/2 in., which usually, justifies rejecting the paving. If the pavement is accepted and if the installation is a "dry system," see procedures under Remedial Methods. The thinnest spacer ring is 1/16 in. If this is too thick, the pavement is under-thick by 11/16 in. Again, if accepted (hardly possible!), see Remedial Methods.

Spacer rings starting at 1/16 in. and flange rings starting at 1/4 in. can be used in increments of 1/16 in. You can combine spacer rings of different thickness, just as you can combine spacer and flange rings. However, avoid using more than three rings if each is less than 3/8 in. thick. Never use more than two rings to make adjustments under 3/8 in.

### **Completing the Installation**

Attach the light fixture to the light base with stainless steel bolts and anti-rotation lock washers, using a torque recommended by the manufacturer of the light base (usually 180-in. lbs.). Provide a thin layer of self-leveling silicone sealer (RTV 118) between the spacer or flange ring and the light base flange. You can use the plywood cover supplied with the light base on top of the spacer or flange ring as a temporary cover. If you expect a long delay before the light fixture is installed, use a steel cover of strength and thickness equal to the light fixture, as well as any adjustment ring necessary. (See Figure 13D, on page 39)



# **Installation of Integrated Inset Lights in New Asphalt Pavement**

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Staking Center Points

Laying the Conduit

Placing the Jigs and Connecting the Light Bases

Anchoring the Light Base

Procedures during Paving

Making the Fixture Flush

Completing the Installation

The light bases used for new flexible (asphalt) pavements consist of at least two pieces a top section and a bottom section. This design is required, for example, when two separate asphalt-paving layers (such as a leveling course and a surface course) are put down separately. The light base must not protrude into the paving material during the compactive effort. If the light base will be set in the subbase and if it requires another base on top of it before the final surface layer is applied, then a third or middle section must be used.

### **Staking Center Points**

The surveyor will stake all center points of inset lights and will set elevations for the compacted subbase and finished pavement. The light's beam may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will stake the center point of the light's position on the centerline of the light beam.

If the light beam will be at an angle to the centerline, the surveyor will stake the center of the light fixture and will also locate two points 4 feet on each side of the center point, on a line through the center point and perpendicular to the centerline of the light beam. Figure 15A, on page 43)

At each center point, make an excavation about 12 in. larger than the diameter of the light base and 6 in. deeper than the bottom of the base. If the base is CTB (cement-treated base), make the opening in the treated base no more than 48 hours after the CTB is placed. Any delay will make excavating difficult. Be careful not to crack or damage the surrounding CTB. A core drill is usually used to make the opening.

### **Laying the Conduit**

When the excavations at the center points of the lights are done, carefully dig a chase into the compacted base that runs between the center points of the light. Make the chase 6-in. wide and 3 in. deeper than the conduit connection to the light base. Carefully remove all excavated material. Lay conduit in the chase and support it so that the conduit's center is 3 in. from the bottom of the chase. Fill the chase with P.C.C. at the same time that the light base is poured. Take care to allow no voids beneath the conduit.

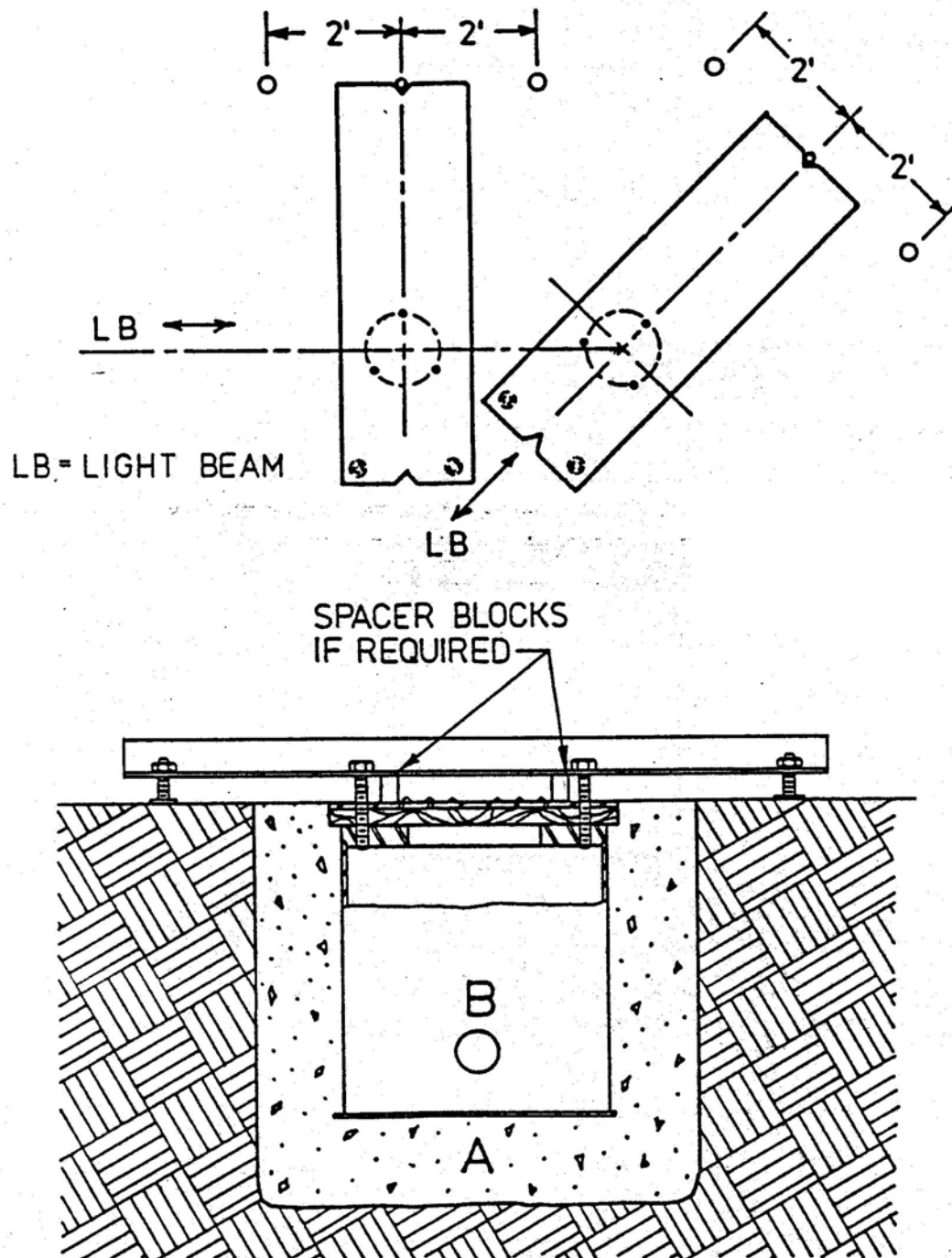
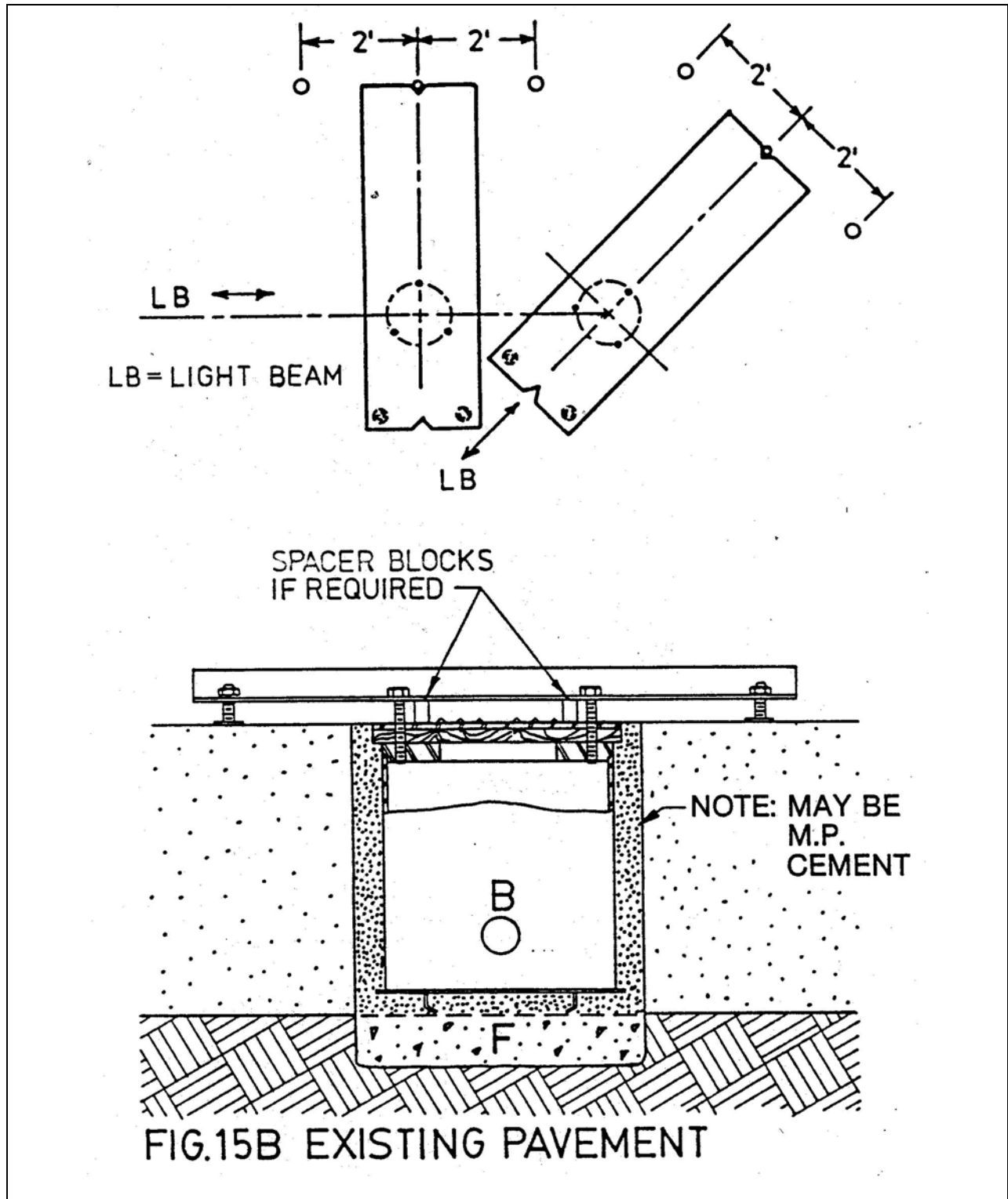


FIG.15A NEW PAVEMENT



## Connecting the Light Bases

The light base assembly includes a plywood cover 5/8-in. thick and a mud plate 1/8 in. thick. Lay the jig (Figure 6A, on page 27) on the compacted subbase over the excavation. (Figure 15A, on page 43) Suspend the light base, with the plywood and mud plate, from the holding plate of the jig into the excavation so that the top of the mud plate is level with the top of the compacted subbase. The bottom of the light base should be 6 in. above the bottom of the excavation.

If the light base has a threaded hub, use a nipple and coupling to make the connection to the light base inside the excavated hole. Steel and other rigid conduits require a waterproof, flexible coupling. Usually, one flexible coupling will suffice for each two-hubbed light base.

If the light base has a grommet opening, insert the conduit into the grommet to make the connection. The depth of penetration into the light base depends on the thermal coefficient of the material the conduit is made of. Steel conduits should enter the light base about 3/4 in. and PVC conduits should enter about 1-1/4 in.

Light bases may have numerous hubs depending on branches in the conduit system. Make all connections now. When planning the installation, remember to place all conduit branches shown on the plans, including drainage stubs, in concrete-filled chases in the subbase of lanes without lights and scheduled for paving before the light bases.

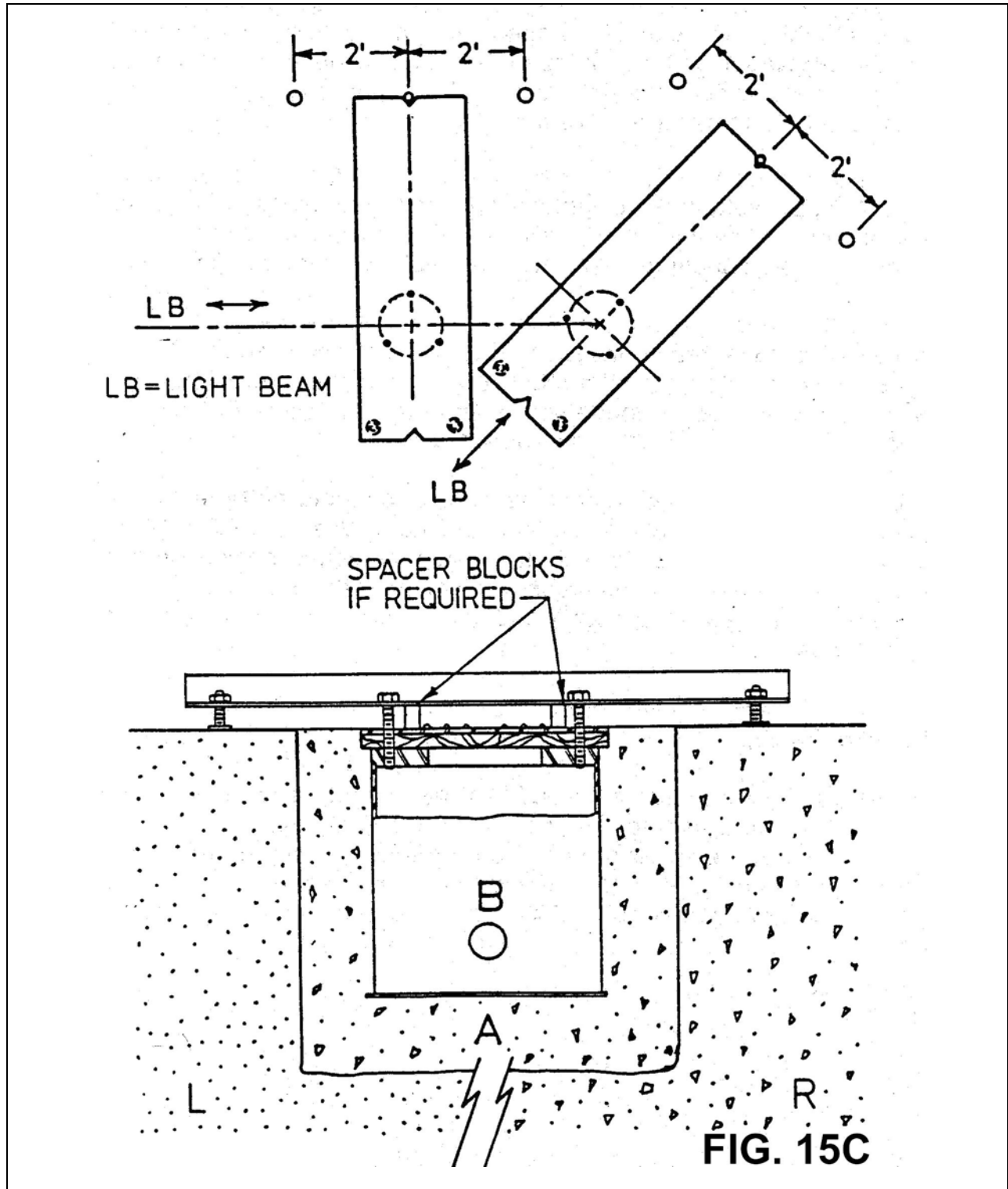
## Placing the Jigs

The jig (Figure 6A, on page 27) straddles the opening and rests on the compacted subbase. (Figure 15A, on page 43) If the light beam is parallel to the centerline, the surveyor can line up the jigs by sighting a transit through the gunsights on the sides of the jig so that he can locate the line through the center point of the light and then chain the distance between lights as shown on the drawings. Usually, if they are in a row, a number of light bases are located at one time.

If the light beam is at an angle with the centerline, the center point of the light is located by using a wire through the two points perpendicular to the light beam and the gun sights on the ends of the jig.

The jig lying on the compacted subbase gives the slope, front to back. You may need to consider the side-to-side slope if the drainage slope of the surface will be obtained by varying the surface thickness. Before pouring the light base, use sandbags to prevent the jigs from moving.

Figure 16L, on page 48, shows the installation sequence. The bottom section (B) is encapsulated in P.C.C. (A) in the excavation to a point level with the top of the mud plate (y). Before the concrete sets, check each light base for azimuth, elevation and slope.



## Procedures during Paving and Coring the Pavement

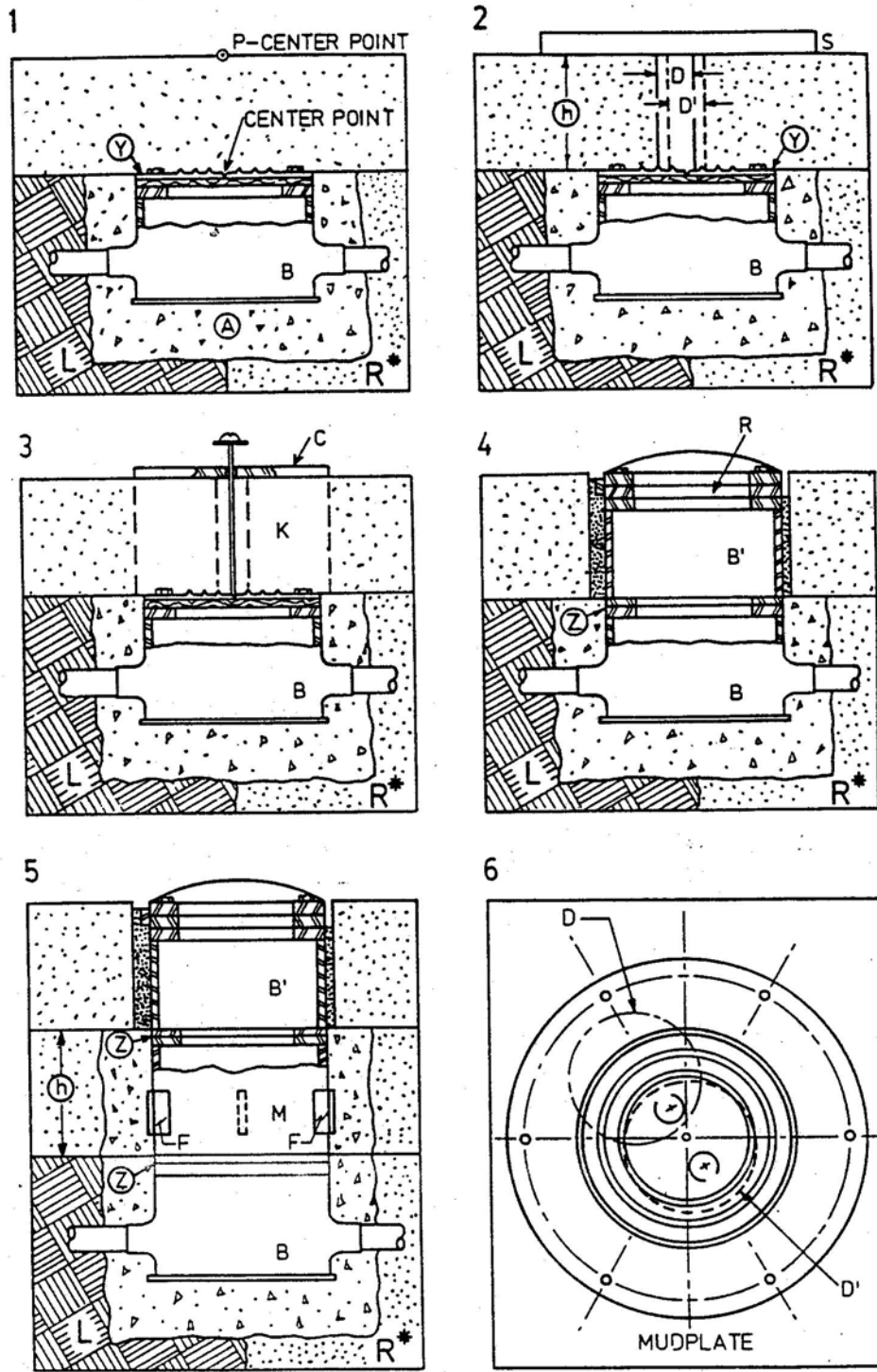
Paving is now ready to begin. Cover the mud plate with a shingle or other thin article when the tack coat is applied prior to paving. Before paving commences, remove the shingle and lightly wipe the mud plate with a rag soaked in vegetable oil.

When paving over the light bases is complete (Figure 16-1, 2, & 3, on page 48), the surveyor should mark the center point (p) for each covered base. Make a 4-in. core (D) to the mud plate. The center mark of the mud Plate (y) should be visible. If it is not, make a second core (D') near the first one, in the direction indicated by the arcs of the mud plate. (Figure 16-6, on page 48) This procedure will expose the center mark.

Using a straightedge (S) across the opening, read the depth of the Pavement (h) over the mud plate. If the pavement surface is uneven or rough, set a pair of blocks of a known and equal height on both sides of the opening, with the straightedge supported on the blocks. Calculate the depth from the surface to the top of the mud plate (h) by subtracting the height of the block from the measurement. Order a top-section (B') assembly (Figure 16-4, on page 48) to bring the light fixture's edge flush with the paved surface, in conjunction with ring (R) 3/4 in. thick. Identify the top section ordered by the light-station number.

When ready to install the inset light, use a compass fixture (C) to scribe a circle on the surface, with the center mark of the mud plate as the center (Figure 17, on page 50). The circle's diameter is a maximum of 1 in. larger than the light fixture. Use the scribed circle to position the coring drill, which is the same size as the circle. Drill the core (K) down to the top of the concrete encasement of the bottom section. (Figure 16-3, on page 48) It is important to use a coring machine of adequate stability to prevent "wobble."

Remove the core, the mud plate and the plywood cover. Apply a thin layer of self-leveling silicone sealer (z) between the flange of the light-base bottom section and the bottom flange of the top section. Bolt the top section to the lower section (B) using a torque recommended by the lightbase manufacturer (usually 180-in. lbs.). (Figure 16-4, on page 48)



\* MAY BE P.C.C. PAVEMENT

FIG. 16



## Installing a Middle-Section Base

If the installation includes a middle-section base, use a middle section (M) (Figure 16-5, on page 48) that is  $\frac{3}{4}$  in. less than "h" high, "h" being the measurement from the pavement surface to the mud plate as determined using the methods outlined above. Make the core 12-in. larger in diameter than the middle section and center it on the center mark of the mud plate. When coring is complete, remove the plywood and mud plate and bolt the middle section to the bottom section (B), using a layer of RTV 118 silicone (z) between the bottom flange of (M) and the top flange of the bottom section (B). Follow "Placing the Jigs", on page 28 and align the middle section to the proper azimuth. Fasten the bolts using a torque recommended by the light base's manufacturer.

A  $\frac{5}{8}$ -in. plywood cover and  $\frac{1}{8}$  in mud plate (y) are part of the middle-section assembly. The middle-section base has slotted holes in its bottom flange that can be used for adjustment of azimuth. A middle-section light base also has fins (f) attached to the sides. These fins lock the middle section into the concrete encasement that is now poured around it and prevent any rotation that might occur due to the slotted holes. Pour the concrete to the level of the top of the mud plate. To install the top section, follow the procedures outlined above for installing a two-piece light base. (Figure 16-4, on page 48)

## Completing the Installation

If the actual elevation of the pavement equals its estimated elevation, the top-section flange will to 1- $\frac{1}{2}$  in. below the surface. This allows for a light fixture  $\frac{3}{4}$  in. thick and a flange or spacer ring  $\frac{3}{4}$  in. thick. If the actual and estimated elevations differ, add or subtract the difference from the ring thickness. (Figure 11, on page 33)

If the system will be "dry system," place a flange ring between the light and the top section. Provide a layer of RTV sealer between the flange ring and the top flange of the top section Next, insert an "o" ring in the groove of the flange ring and then fasten the light by bolting it to the light base using anti-rotational washers at a torque recommended by the light base's manufacturer (usually 180 in. lbs.).

If the system will be a "wet system," place a spacer ring between the light and top section and bolt the light fixture to the top flange, using anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180 in. lbs.).

**Important:** Using the ring allows you to lower the light fixture in the future. This may be required if the pavement slumps in warm temperatures or under heavy traffic. Since the light base is well supported and will hold its elevation if the pavement drops off, replacing the spacer ring or flange ring with a thinner one allows you to lower the light, thereby adapting it to the pavement.

If a long delay is anticipated before the light fixtures are installed, use a steel cover of strength and dimensions equal to the light fixture in the space left for the fixture.

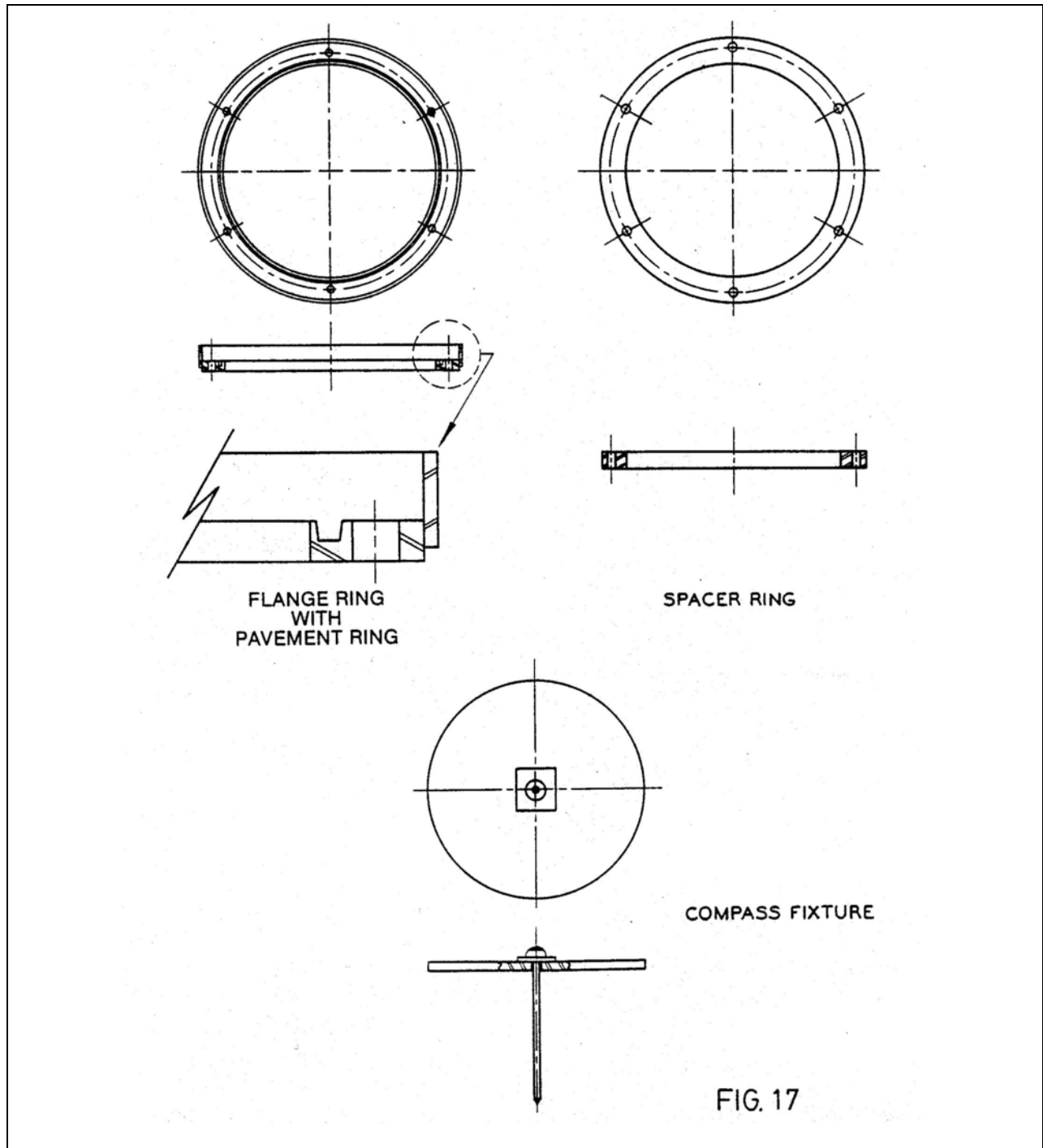


FIG. 17

Fill the space between the light fixture and the pavement with a soft bituminous sealer, such as P-605. If a hard sealer is specified, use a P-606 sealer compatible with bituplastic materials. Fill the crevasse no higher than the bottom of the flange ring. If the light base assembly has a pavement ring (Figure 17, above) on the top flange of the base, fill the crevasse up to 1/8 in. from the surface.

# **Installation of Integrated Inset Lights in Pavement Overlays**

Overlays become necessary when the original pavement has been degraded by traffic, weather and insufficient subbase support and also when a more skid-resistant surface is desired. The usual overlay is an asphaltic type, but P.C.C. has been and can be used. The minimum thickness is 6 in. when using concrete that is not reinforced. Asphalt overlays vary in thickness depending on the condition of the pavement being overlaid and the number of courses needed to achieve the final elevation and surface texture.

Now is an excellent time for an airport to contemplate installing inset lights – and to **plan**. Even if, the installation is scheduled in the future, serious consideration should be given to placing the interface for inset lights at the time the earlier paving is done. The reason for this is that, without proper planning, the preparatory work will be duplicated when the lighting system finally is installed. For instance, poor planning may necessitate tearing up fairly new pavement, creating downtime at the facility and duplicating much of the downtime created by the original paving. Investing in the inset lighting interface – even, if it lies unused for five years – is still far cheaper than the cost of a fully separate installation.

In general, placing an inset lighting system during an overlay follows the methods described earlier here for the type of paving materials used.

If a new system will be installed during the overlay, consider the existing pavement as the subbase. The methods described in the overlay sections apply to completely resurfacing the pavement (or part of it while leaving the existing pavement in place).

# Installation in Asphalt Overlays

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Staking Center Points and Coring the Pavement  
Laying the Conduit  
Connecting the Light Bases  
Placing the Jigs  
Preparing for Paving and Coring the Pavement  
Completing the Installation

## Staking Center Points and Coring the Pavement

The surveyor will mark all center points of inset lights on the pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will mark the center point of the light's location on the centerline of the light beam. If the light beam will be at an angle to the centerline, he will mark the center of the light fixture and will also locate two points that lie 4 feet on each side of the center point, on a line through the center point and perpendicular to the centerline of the light beam.

Core a hole in the existing pavement 12 in. larger than the diameter of the light base and deep enough to accommodate the bottom-section light base (B) (Figure 15B, on page 44 C, on page 46). This will contain transformers, primary cables and connectors. When the pavement is cored for the bottom section, make certain that the pavement under it is capable of supporting the loads and impact that will be imposed on the light fixture. If any doubt exists about the ability of the remaining pavement and the subbase to give the necessary support, core the hole completely through the pavement to leave a 6 in. opening below the base for P.C.C Concrete, (F).

## Laying the Conduit

When the holes at the center points of the lights are completed, carefully cut a chase, 6 in. wide and 3 in. deeper than the conduit connection to the light base—into the pavement between the center point of the light bases. Carefully remove all excavated material. Lay conduit (C) in the chase and support it so that the center of the conduit is at least 3 in. above the bottom of the chase. Fill the chase with P.C.C. at the same time that the light base is poured. Be careful to allow no voids beneath the conduit.

If the total thickness of the asphalt will be more than 3 in., fill the chase with P.C.C. If the asphalt will be less than 3 in. thick, fill the chase only to the level that will still allow a 3-in. thickness of pavement over the chase. When the chase is completely filled with concrete (and it will be if the thickness of pavement is 3 in. or more) the concrete should be level with the existing pavement to prevent reflective cracking. The concrete is usually placed when the light base is poured. (Fig 14A, on page 55)

The bottom-section light base assembly includes a plywood cover 5/8-in. thick and a mud plate 1/8 in. thick. Lay the jig (Figure 6A, on page 27) on the old pavement over the cored hole. (See Figure 15B on page 44, C on page 46) Suspend the bottom section, with the plywood and mud plate, from the holding plate of the jig down into the hole so that the top of the mud plate is level with the old pavement. If the overlay will be less than 3 in thick, set the top of the mud plate below the elevation of the old pavement by the amount under 3 in. that the overlay will be. For example, if the overlay will be 2 3/4 in. thick, set the top of the mud plate 1/4-in. below the top of the old pavement. This setting is particularly important when the overlay is chamfered to a thin section to match the elevation of the adjacent, unoverlaid pavement.

Use rigid steel conduit for asphalt overlays that will be less than 2 in thick. If calcium aluminate concrete is used this can be 1 in. thick since heat from the paving material is the

problem. If the pavement is chamfered to meet grade with thin sections of overlay and if the conduit must be kept level with the rest of the system—special consideration of the height of light bases may be required to make L' (Figure 14B below) the right dimension.

### CONDUIT CHASE PLACEMENT

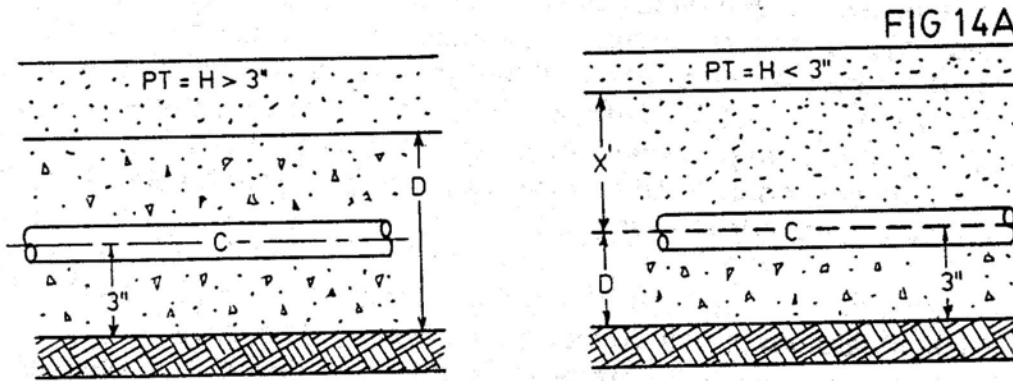


FIG 14A

PT = PAVEMENT THICKNESS  
 H = OVERLAY THICKNESS  
 X = DISTANCE MUDPLATE BELOW SURFACE  
 A = CONCRETE PLACEMENT

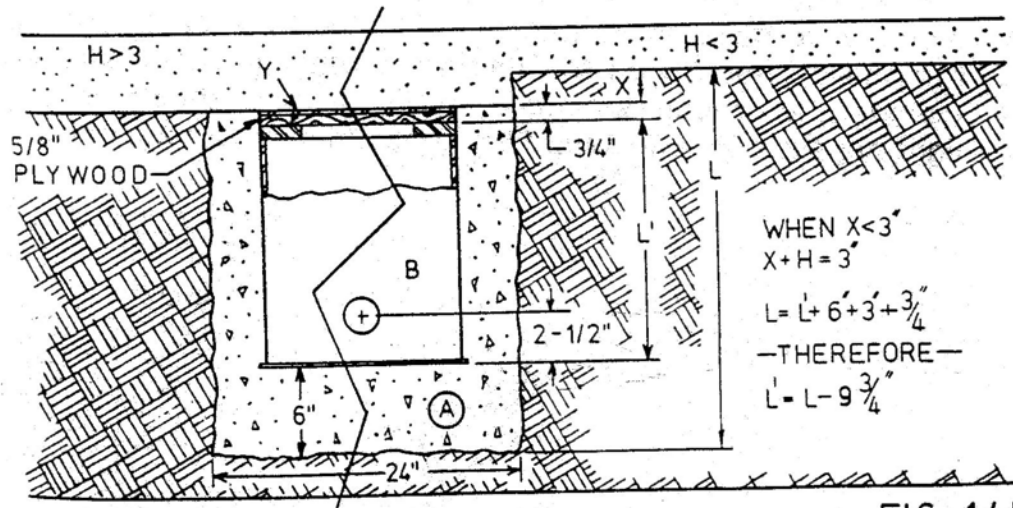
$$D = L' - 2\frac{1}{2} + 4$$

— THEREFORE —

$$D = L' + 1\frac{1}{2}$$

X' = H + 3 = AMOUNT PAVEMENT OVER CHASE  
 D = DEPTH OF PCC FILL  
 C = CONDUIT  
 L = DEPTH OF HOLE  
 L' = DEPTH OF LIGHTBASE

### LIGHT BASE PLACEMENT



WHEN  $X < 3'$   
 $X + H = 3'$   
 $L = L' + 6' + 3' + \frac{3}{4}$   
 — THEREFORE —  
 $L' = L - 9\frac{3}{4}$

FIG. 14 B

## Connecting the Light Bases

If the bottom section has threaded hubs, use a nipple and coupling to make the connection to the light base inside the cored holes. If the conduit is steel or rigid, use a waterproof, flexible coupling. Usually one flexible coupling will suffice for each two-hubbed light base.

If the light base has a grommet opening, insert the conduit into the grommet to make the connection. The depth of penetration into the light base depends on the thermal coefficient of expansion of the material the conduit is made of. Steel conduits should enter into the light base about 3/4 in. and PVC conduits should enter about 1-1/4 in.

Light bases may have any number of entrances depending on branches in the conduit system. Make all connections now. Place all conduit branches having no lights (including drainage stubs) in encapsulated chases if they are to be paved over before lanes with light bases are placed.

## Placing the Jigs

The jig (Figure 6A, on page 27) straddles the excavation and rests on the existing pavement. (Figure 15C, on page 46).

If the light beam is parallel to the centerline the surveyor can line up the jig(s) by sighting a transit through the gun sights on the sides of the jig so that he can locate the line through the center point of the light. He can then chain the distance between lights as shown on the drawings. Usually, if the lights are in a row, a number of them are located at the same time.

If the light beam is at an angle with the centerline, the center point of the light is located by using a wire through the two points perpendicular to the light beam and the gun sights on the ends of the jig.

The jig lying on the pavement gives the slope, front to back. You may need to consider the side-to-side slope if the drainage slope of the surface will be obtained by varying the surface thickness. Before pouring the light bases, use sandbags to prevent the jigs from moving.

Figure 16,R, on page 48, shows the installation sequence. The bottom section (B) is encapsulated in P.C.C. (A) in the excavation to a point level with the top of the mud plate (y). Before the concrete sets, check each light base for azimuth, elevation and slope. If the thickness (h) of the overlay will be less than 3 in., set the top of the mud plate below the elevation of the old pavement by the amount under 3 in. that the overlay will be. For example, if the overlay will be 2 3/4 in. thick, set the top of the mud plate 1/4-in. below the top of the existing pavement. (Figure 14B, on page 55)

To ready the pavement for traffic in the shortest possible time, using a quick-setting Magnesium Phosphate concrete will allow the paving to begin within 24 hours. Take care when using a quick-setting cement (such as one containing gypsum) that its water-absorption rating is low (2% maximum) to prevent future swelling and distortion of the surface. If Magnesium Phosphate cement is used, reduce the core opening diameter (C) by as much as 6 in.



## Preparing for Paving and Coring the Pavement

Paving is now ready to begin. Cover the mud plate with a shingle or other thin article when the tack coat is applied prior to paving. Before paving commences, discard the shingle and lightly wipe the mud plate with a rag soaked in vegetable oil.

When paving over the light bases is complete (Figure 16-1,R, 2,R, on page 48), the surveyor should mark the center point (p) for each covered base. Make a 4-in. core (D) to the mud plate. The center mark of the mud plate (y) should be visible. If it is not, make a second core (D') near the first one, in the direction indicated by the arcs of the mud plate. (Figure 16-6R, on page 48) This will expose the center mark.

Using a straightedge (S) across the opening, read the depth of the pavement (h) over the mud plate. If the pavement's surface is uneven or rough, set a pair of blocks of a known and equal height on both sides of the opening, with the straightedge supported on the blocks. Calculate the depth from the surface to the top of the mud plate (h) by subtracting the height of the block from the measurement. Order a top-section assembly (B') (Figure 16-4, on page 48) to bring the light fixture's edge flush with the paved surface, in conjunction with a ring (R) 3/4 in. thick. Identify the top section ordered by the light-station number.

When ready to install the inset lights, use a compass fixture (C) to scribe a circle on the surface, with the center mark of the mud plate as the center. (Figure 17, on page 50) The circle's diameter is a maximum of 1 in. larger than the light fixture. (Figure 16-3, on page 48) Use the scribed circle to position the coring drill, which is the same size as the circle. Drill the core (K) down to the top of the concrete encasement of the light base. It is important to use a coring machine of adequate stability to prevent "wobble."

Remove the core, mud plate and plywood cover. Apply a thin layer of self-leveling silicone sealer (z) between the bottom flange of the top section and the top flange of the bottom section. (Figure 16-4, on page 48) Bolt the top section (B') to the lower section (B) using a torque recommended by the manufacturer of the light base (usually 180-in. lbs.)

## Completing the Installation

If the actual elevation of the pavement equals the estimated elevation, the top-section flange will be 1-1/2 in. below the surface. This allows for a light fixture 3/4 in. thick and a flange or spacer ring (R) 3/4 in. thick. (Figure 11, on page 33) If the actual and estimated elevations differ, add or subtract the difference from the ring thickness.

If the system will be a "dry system," place a flange ring between the light and the top section. Apply a layer of RTV self-leveling sealer between the flange ring and the top flange of the top section. Next, insert an "o" ring in the groove of the flange ring and then fasten the light by bolting it to the light base using anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180 in. lbs.).

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If the system will be a "wet system," place a spacer ring between the light and top section and bolt the light fixture to the top flange by bolts and anti-rotational washers, using a torque recommended by the light base manufacturer (usually 180 in. lbs.).

**Important:** Using the ring allows you to lower the light fixture in the future. This may be required if the pavement slumps in warm temperatures or under heavy traffic. Since the light base is well supported and will hold its elevation if the pavement drops off, replacing the spacer ring or flange ring with a thinner one allows you to lower the light, thereby adapting it to the pavement.

If you expect a long delay before the light fixtures are installed, use a steel cover of strength and dimensions equal to the light fixture in the space left for the fixture.

Fill the space between the light fixture and the pavement with a soft bituminous sealer, such as P-605. If a hard sealer is specified, use a P-606 sealer compatible with bituplastic materials. Fill the crevasse no higher than the bottom of the flange ring. If the light base assembly has a pavement ring on the flange ring, fill the aperture up to 1/8 in. from the surface. (Figure 11, on page 33)

# Installation in Portland Cement Concrete Overlays

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Marking Center Points  
Laying the Conduit  
Connecting the Light Bases  
Placing the Jigs  
Connecting the Light Bases  
Casting the Overlay  
Making the Fixture Flush  
Completing the Installation

P.C.C. overlays are uncommon. They must be a minimum of 6 in. thick. They are usually laid on an existing concrete pavement and sometimes on an asphalt leveling course that is laid between the concrete layers.

### **Marking Center Points**

The surveyor will mark all center points of inset lights and will set elevations for the finished pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will mark the center point of the light location on the centerline of the light beam. If the light beam will be at an angle to the centerline, he will mark the center of the light fixture and will also locate two points that lie 6 feet on each side of the center point, on a line through the center point and perpendicular to the center line of the light beam. (Figure 20, on page 79)

### **Laying the Conduit**

Carefully cut a chase, 2 in. wider and 3 in. deeper than the conduit, into the pavement between the center points of the light bases. Carefully remove all excavated material. Lay conduit in the chase and support it so that the center of the conduit is 3 in. from the bottom of the chase. Fill the chase with P.C.C. Use Magnesium Phosphate concrete if time is important. Pour the chase at the same time the bases are encapsulated. When the chase is completely filled with concrete, it should be level with the pavement.

### **Coring the Pavement**

At each light's center point, core a hole 12-in. larger than the diameter of the light base if P.C.C. is used to encapsulate it. If Magnesium Phosphate Cement will be used, make the hole 4-in. larger than the light base. During the process, make certain that the pavement under the base is capable of supporting the loads and impact that will be imposed on the light. If any doubt exists about the ability of the remaining pavement and the subbase to give the necessary support, core the hole completely through the pavement to leave an opening 6 in. below the light base. (F).

### **Placing the Jigs**

The jig (Figure 6B, on page 27) straddles the excavation and rests on four adjustable legs. (Figure 21A, on page 62) The surveyor can line up the jig(s) by sighting a transit through the gunsights on the sides of the jig so that he can locate the line through the center point of the light. He can then chain the distance between lights as shown on the drawings. For radial locations, the surveyor locates the center point of the light through the gun sights on the sides of the jig using a wire through the two points perpendicular to the light beam and the gun sights on the ends of the jig. Unless the pavement's drainage slope will change, the jig, will be set at the right slope (front-to-back and side-to-side) if its legs are equal in length. If the light will be for airborne guidance, set the jig level. If the drainage slope will change, adjust the height of the jig's legs.

The light base assembly includes a 5/8-in. thick plywood cover and a 1/8-in. thick steel mud plate. The light base assembly should be set 3/4 in. below the holding plate. Do this by using long bolts or using a spacer built into the jig.

### Connecting the Light Bases

If the light base has a threaded hub, use a nipple and coupling to make the connection to the light base in side the excavated hole. If the conduit is steel or rigid, use a waterproof, flexible coupling. Usually, one flexible coupling will suffice for each two-hubbed light base.

If the light base has a grommet opening, insert the conduit into the grommet to make the connection. The depth of penetration into the light base depends on the thermal coefficient of expansion of the material the conduit is made of. Steel conduits should enter into the light base about 3/4 in. and PVC conduits should enter about 1-1/4 in.

Light bases may have numerous entrances depending on branches in the conduit system. Make all connections now. Place all conduit branches (including drainage stubs) shown on the plans in concrete-filled chases if they are paved before lanes with bases.

When the jig and base assembly has been checked for alignment and the light base is set at the proper azimuth, elevation and slope, weight the jig with sandbags to prevent movement.

Encapsulate the base assembly (B) in the pavement up to a level even with the top of the old pavement (G-G'). (Figure 21A, on page 62) Take care that the material used does not intrude into the overlay space. It is good practice to recheck azimuth, elevation and slope before the concrete anchor has set. Allow the light-base anchor to cure until the concrete reaches adequate strength. The jig can be removed 24 hours later, but protect the base from being struck by moving vehicles and equipment. If you use Magnesium Phosphate concrete, it will set in one hour or less. Exercise caution with this material: once set, it is difficult to remove.

### Casting the Overlay

When the overlay is ready to be cast along with the light bases, remove the plywood cover and bolt only the mud plate to the light base. The paving can now proceed normally. A thickness of 1-3/8 in. of wet concrete will cover the light-base assembly. (Fig: 21C, on page 63) During the process, a bridge spanning the paving lane behind the paving train stops at each buried light base. A worker on the bridge directly over the light base inserts a "cookie cutter" (a thin metal hoop slightly larger in diameter than the base and about 5 in. high) around the base and works it down into the wet concrete at least 1 in. below the base's top. (Figure 8, on page 30).

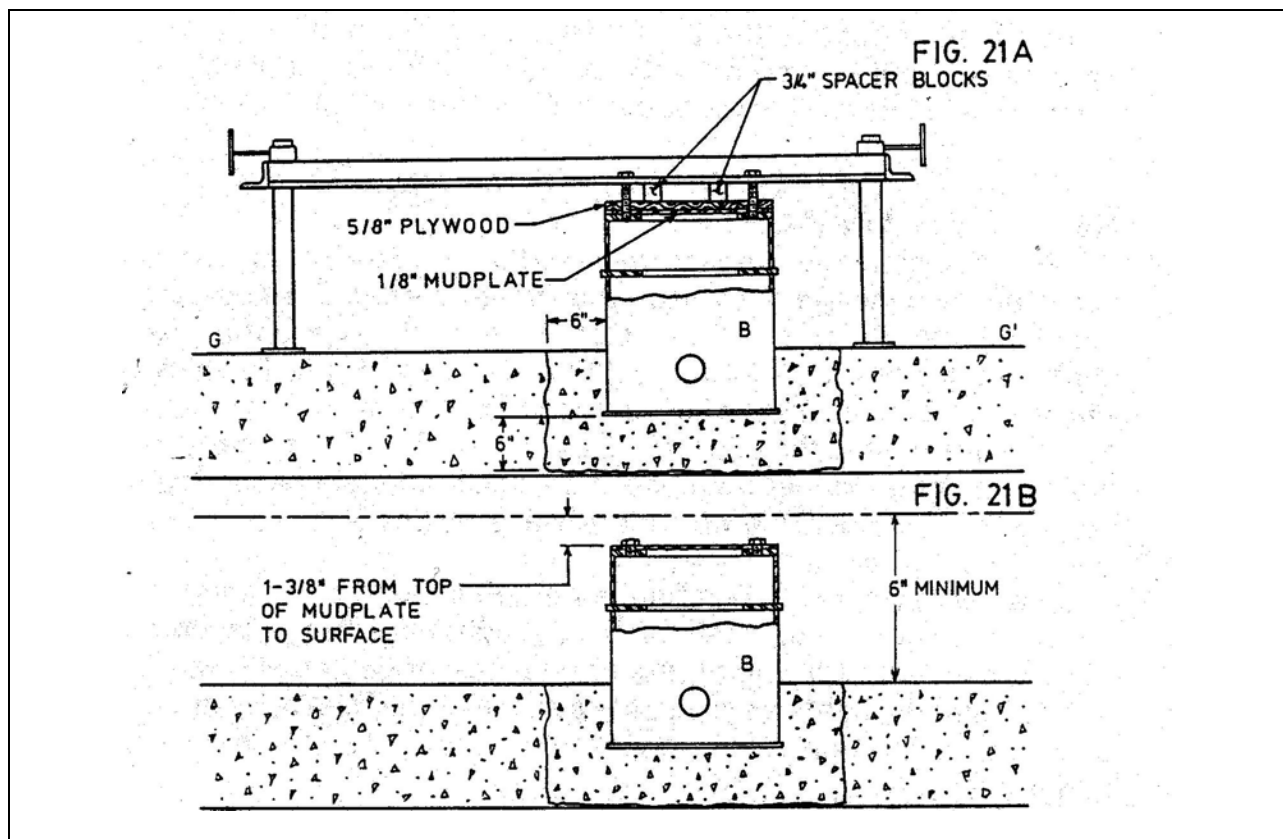
**Note:** Locating the light base is not difficult: an experienced worker will recognize the location by its slightly different appearances if needed, though, the longitudinal location in the pavement can be marked for reference on opposite sides of the lane.

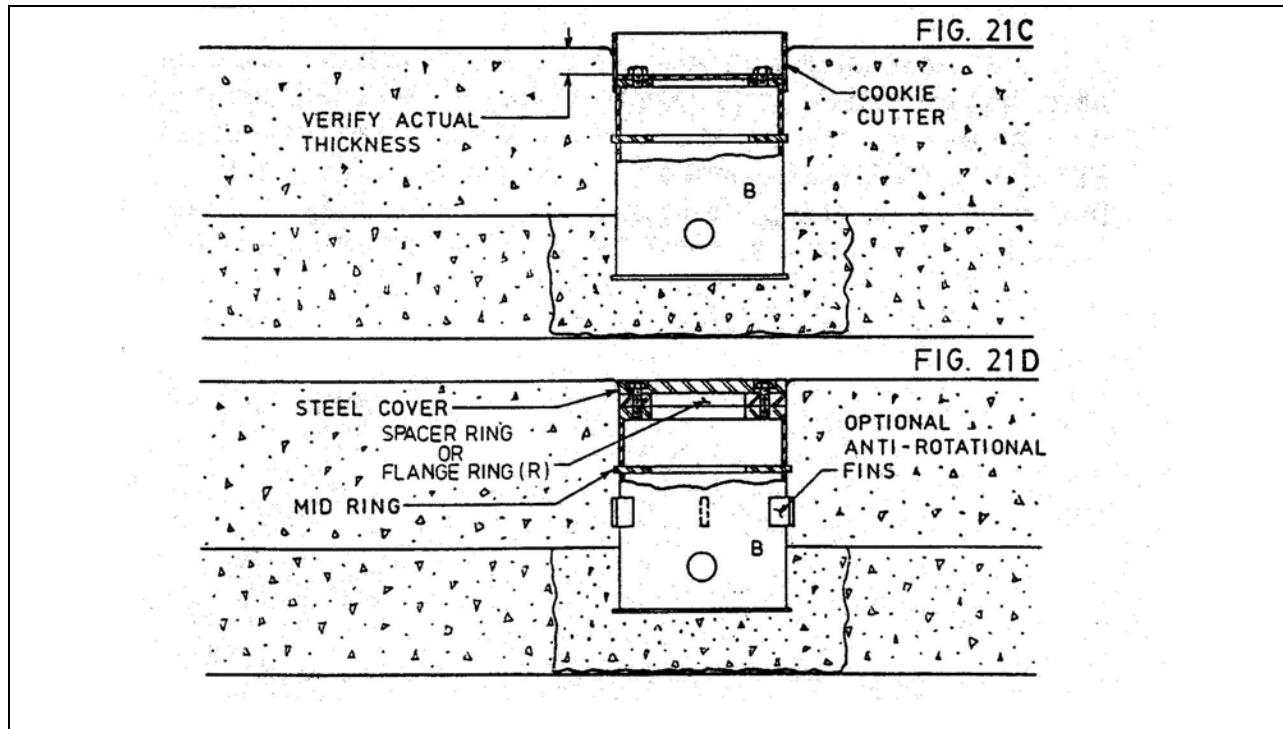
The worker on the bridge carefully removes the wet concrete inside the hoop down to the mud plate. He then removes the mud plate, cleans the top flange of the light base and makes sure

no wet concrete adheres to the bottom of the mud plate before rebolting it to the light base. If the surface of the wet paving outside the cookie cutter has been disturbed, he repairs it, making sure that the concrete outside the cookie cutter is level with the paving. He finishes the edge around the cookie cutter with a special curved trowel (Figure 9, on page 30) to provide a radius around the edge of the opening.

**Note:** Wiping the cookie cutter with a light vegetable oil before inserting it makes its removal later on easier.

Some plans require the pavement be laid down in more than one pass. This is unlikely on a P.C.C. overlay, but if it is required, see the section on "in-Space" Installation in P.C.C. Pavement.





### Making the Fixture Flush

When the concrete has set, remove the cookie cutters. The actual depth of the concrete is measured between the top of the paving and the mud plate. Remove the mud plate. If the pavement is the specified thickness, insert a spacer ring (R) (Figure 21D, above) 3/4-in. thick. This will leave a space the thickness of the light from the surface. If the pavement is thicker than specified, use a thicker or extra spacer ring. If the pavement is thinner than specified, use a thinner spacer ring to bring the light fixture flush with the surface.

On a "dry system," use a flange ring (R) instead of a spacer ring. If the thickness of the concrete above the light base flange is more than 1-1/2 in., use a spacer ring of proper thickness together with the flange ring to bring the light flush with the surface. If the thickness of the concrete above the light base flange is less than 1-1/2 in., use a thinner flange ring.

The thinnest flange ring possible is 1/4 in. thick. If this is too thick, the paver has missed the thickness by 1/2 in., which usually justifies rejecting the paving. If accepted, for a dry system, see procedures under Remedial Methods, Section 1. The thinnest spacer ring is 1/16 in. If this is too thick, the pavement is under thick by 11/16 in. Again, if accepted, (hardly possible), see Remedial Methods, on page 101.

Spacer rings starting at 1/16 in. and flange rings starting at 1/4 in. can be used in increments of 1/16 in. You can combine spacer rings of different thickness, just as you can combine spacer and flange rings. However, avoid using more than three rings if each is less than 3/8 in. thick. Never use more than two rings to make adjustments under 3/8 in.

### **Completing the Installation**

Attach the light fixture to the light base with stainless steel bolts, using anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180-in. lbs.). Provide a thin layer of self-leveling silicone sealer between the spacer or flange ring and the light base flange. You can use the plywood cover supplied with the light base on top of the spacer or flange ring as a temporary cover. If you expect a long delay before the light fixture is installed, use a steel cover of strength and thickness equal to the light fixture, as well as any adjustment ring necessary. (Figure 21D, on page 63).



# **Reinstallation of Inset Lights in Overlaid Pavements**

If inset lights will be reinstalled in the overlay of pavements that already have inset lights, the procedure is simply to raise the lights to the elevation of the new surface.

If glue-in system bases (Figure 22A, on page 69) are firmly fixed in the pavement, the existing bases can be used.

If the system is a non-conduit glue-in system and if the overlay will be more than 3 in. thick, this is a good opportunity to upgrade it to the appropriate conduit system described in the next sections.

# Reinstallation in Asphalt Pavement Overlays

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Preliminary Steps  
Laying the Conduit  
Removing Loose Bases  
Marking Center Points  
Placing the Jigs  
Preparing for Paving and Coring the Pavement  
Completing the Installation

On a system that will be used as is, replace the light fixtures during paving with a  $\frac{1}{2}$  in. plywood cover mounted by a mud plate. Proceed with the overlay paving as described in the section below titled "Preparing for Paving" on page 57.

If a conduit system upgrade will replace the glue-in conductors, follow the applicable procedures below before the overlay is applied.

### **Preliminary Steps**

Cut and abandon the secondary conductors (W) (Figure 22A, on page 69) inside the base. If the glue-in system has a junction box outside the light base, the conductors can be cut at the splice in the junction box.

### **Laying the Conduit**

Carefully cut chases for 1-in. diameter conduits in the pavement. Make the chases 4 in. wide and 5 in. deep between the light bases and also the transformer housings at the edge of the pavement.

Next, drill a hole into the side of the glue-in shallow base close to the bottom to connect a 1-in. diameter conduit to the base. Insert a 1-in. diameter steel conduit that is adequate for the secondary conductors  $\frac{3}{4}$  in. into the base. Fasten a  $\frac{5}{8}$ -in. plywood cover mounted by a  $\frac{1}{8}$ -in. mud plate to the glue-in base. Support the conduit in the chase and encapsulate it with P.C.C. (or with Magnesium Phosphate Concrete). When the chase is completely filled with concrete, the concrete should be level with the old pavement to prevent reflective cracking.

Install the conduits in the same pattern as used in the glue-in system. (Figure 23A or B, on page 78) Connect the 1-in. conduits to the transformer housings off the edge of the pavement where the secondary conductors will be connected to the isolating transformer. The glue-in conduit system light base is now ready for paving.

### **Removing Loose Bases**

Use a core drill  $\frac{1}{2}$  in. larger in diameter than the bases being replaced if the encapsulating material will be a P-606 adhesive compatible with bituplastic materials, or 2 in. larger if Magnesium Phosphate is used. Make the core  $\frac{1}{2}$ -in. deeper than the replacement light base. (See Note: on page 72) When the pavement is cored, make certain that the pavement under it is capable of supporting the loads and impact that will be imposed on the light fixture. If any doubt exists about the supportability of the remaining pavement at the bottom of the core, or of the subbase under it, core the hole completely through the pavement to leave a 6-in. opening below the base. (F) The new base (Figure 22D, on page 69) is supplied with a plywood cover  $\frac{5}{8}$  in. thick and a mud plate  $\frac{1}{8}$  in. thick.

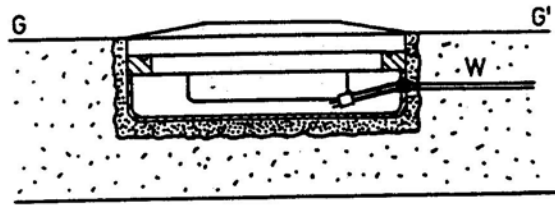


FIG. 22A

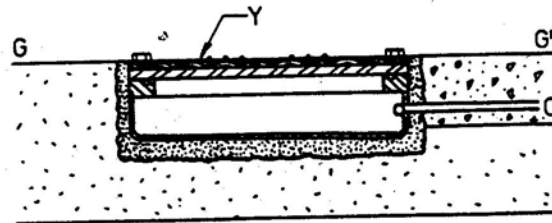


FIG. 22B

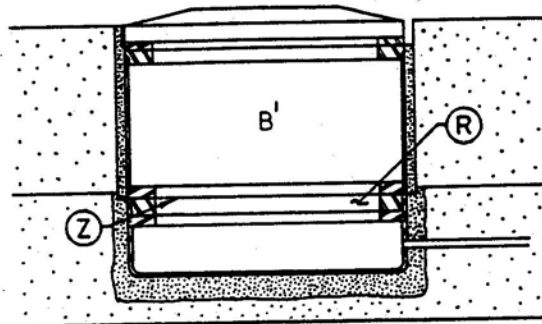


FIG. 22C

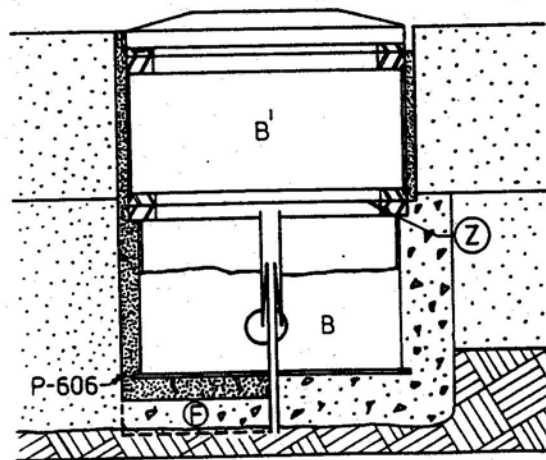


FIG. 22D

## Marking Center Points

The surveyor will mark all center points of inset lights of the replacement bases and will set elevations for the finished pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will mark the center point of the light's location on the centerline of the light beam. If the light beam will be at an angle to the centerline, he will mark the center of the light fixture and also locate two points that lie 4 feet on each side of the center point, on a line through the center point and perpendicular to the centerline of the light beam.

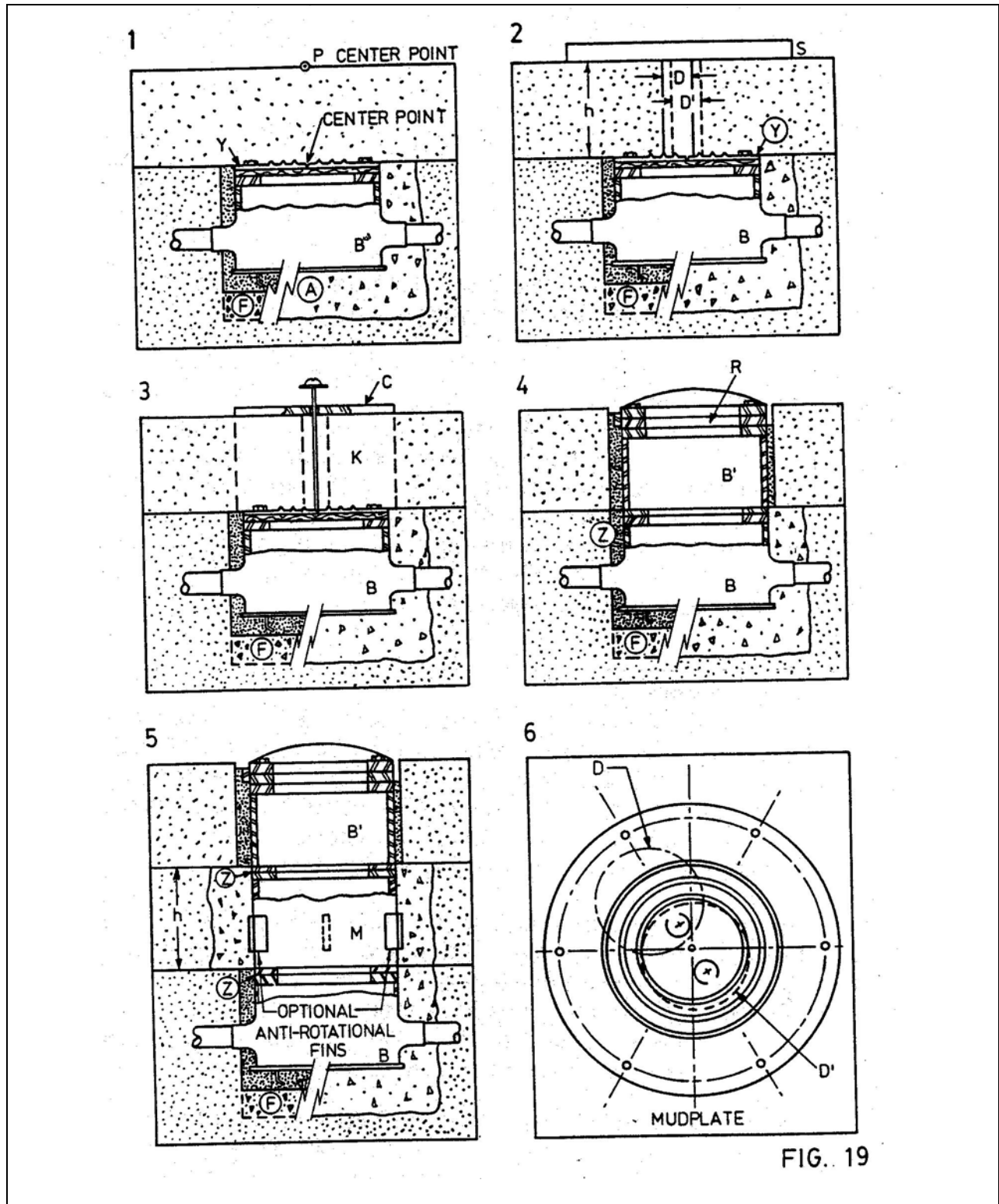
## Placing the Jigs

Lay a jig (Figure 6A, on page 27) on the old pavement over the cored hole. (Figure 18A,R, on page 88) Suspend the new light base (with the 5/8-in. plywood and 1/8 in. mud plate attached) from the holding plate of the jig down into the hole. Position the base so that the top of the mud plate is level with the top of the old pavement and the bottom of the light base is 1/2 in. above the bottom of the excavation. The surveyor can line up the jig(s) by sighting a transit through the gunsights on the sides of the jig to locate the line through the center point of the light and then chain the distance between lights as shown on the drawings. For angular locations, locate the light's position by using a wire through the two points perpendicular to the light beam and the gunsights on the ends of the jig. Once the jigs are correctly placed, use sandbags to keep them from moving during and after the pouring of the light bases.

Figure 19, on page 71, shows the installation sequence. The base (B) and conduits (C) are encapsulated (A) in the excavation up to the level of the top of the mud plate (y). Before the concrete sets, check those that have been placed for azimuth, elevation and slope.

## Preparing for Paving

If the existing base in the old pavement has a concrete ring (Figure 22C, on page 31) as part of the top flange, allow for an extra 5/8 in. spacer ring to go between the bottom of the extension and the flange of the old base. The paving process may now proceed. Cover the mud plate with a shingle or other thin article while the tack coat is applied and remove the shingle prior to paving. Before paving begins, lightly wipe the mud plate with a rag soaked in vegetable oil.



## Coring the Pavement

When paving over the light bases is complete, the surveyor should mark the center point (p) for each covered base. (Figure 19-6, on page 71) Make a 4-in. core (D) down to the mud plate. The center mark of the mud plate should be visible. If it is not, make a second core (D') next to the first one, in the direction indicated by the embossed arcs of the mud plate. This procedure will expose the center mark.

Using a straightedge (S) across the opening, read the depth of the pavement (h) over the mud plate. If the pavement's surface is uneven or rough, set a pair of blocks of a known and equal height on both sides of the opening, with the straightedge supported on the blocks. Calculate the depth from the surface to the top of the mud plate (h) by subtracting the height of the block from the measurement.

Order a top section assembly (B) to bring the light fixture's edge flush with the paved surface, in conjunction with a ring (R) 3/4 in. thick. (Figure 19-4, on page 71) Identify extensions ordered by the light-station number.

**Note:** If the overlay will be less than 3 in. thick, the bases will be required to be set below the elevation of the existing pavement. See Figure 18B,L, on page 89 and read "Installation in Asphalt Overlays", on page 53.

When ready to install the inset light, use a compass fixture (Figure 17, on page 50) to scribe a circle on the surface, with the center mark of the mud plate as the center. The circle's diameter is usually 1/2 in. larger than the light fixture. However, when the bottom base is a glue-in, the scribed circle is 1 in. larger in diameter. This is because bolt-head clearance requires the extension to be 1/2 in. larger in diameter than a light base top section, although the top flange bolt circle will be to the standard bolt diameter. Use the scribed circle to position the coring drill, which is the same size as the circle. Drill the core (K) (Figure 19-3, on page 71) down to the top of the original pavement or to the encasement of the bottom section. It is important to use a coring machine of adequate stability to prevent "wobble."

Remove the core, the mud plate and the plywood cover. Apply a thin layer of self-leveling silicone sealer (z) between the flange of the light-base bottom section and the bottom flange of the top section. Bolt the top section (B') to the lower section (B) with stainless bolts and anti-rotational washers using a torque recommended by the manufacturer of the light base (usually 180-in. lbs.).

## Completing the Installation

If the actual elevation of the pavement equals the estimated elevation, the extension flange will be 1-1/4 to 1-1/2 in. below the surface depending upon the ring thickness. This allows for a light fixture 3/4 in. thick and a flange or spacer ring 1/2 or 3/4 in. thick. If the actual and estimated elevations differ, add or subtract the difference from the ring thickness. (Figure 11, on page 33)



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On a "dry system," place a flange' ring between the light and the top section. Provide a layer of RTV sealer between the flange ring and the top flange of the top section. Next, insert an "o" ring in the groove of the flange ring and then fasten the light by bolting it to the light base using anti-rotational washers at a torque recommended by the light base's manufacturer (usually 180 in. lbs.).

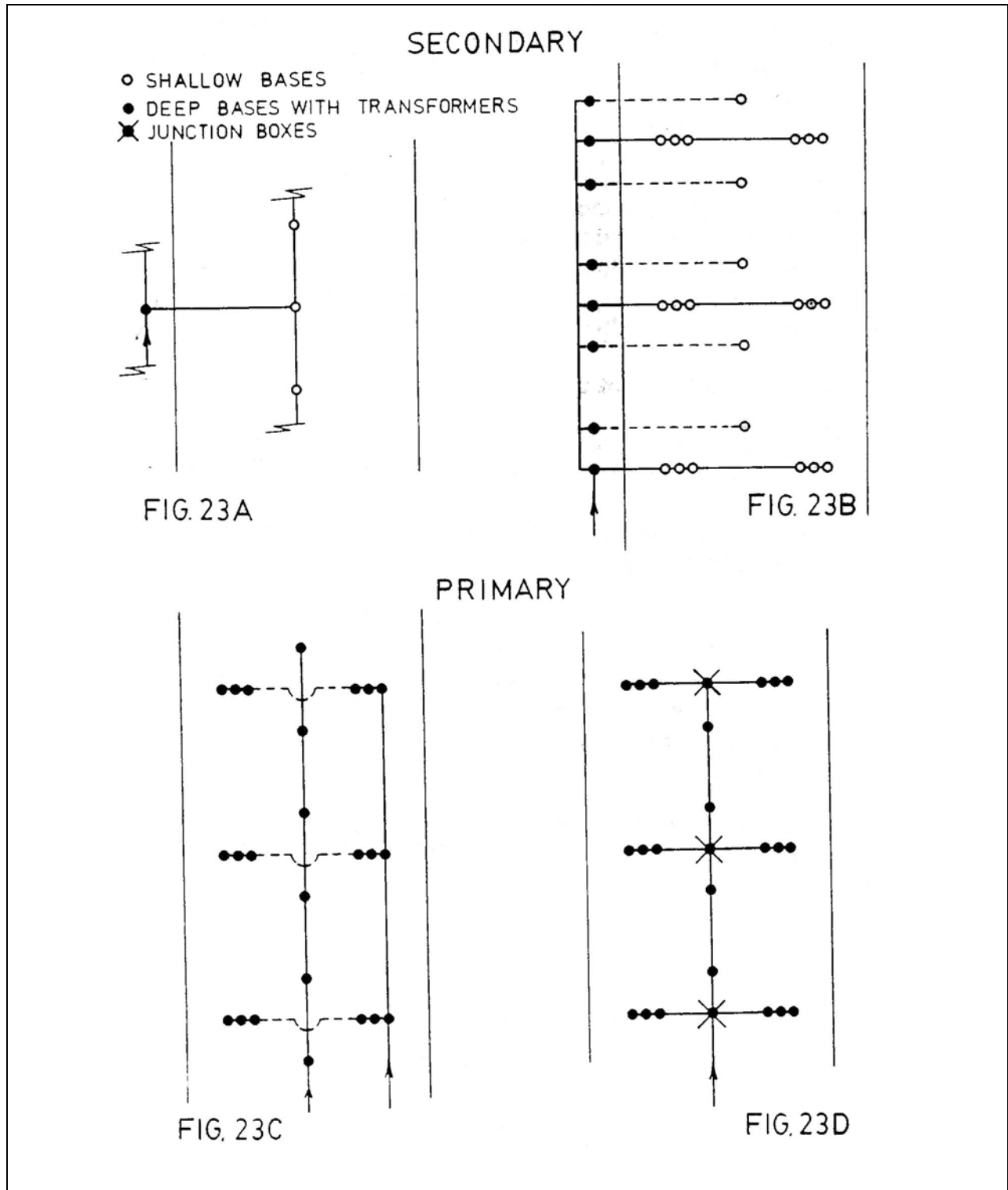
If the system will be a "wet system," place a spacer ring between the light and top section and bolt the light fixture to the top flange, using anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180 in. lbs.).

**Important:** Using the ring allows the light to be lowered in the future. This may be required if the pavement slumps in warm temperatures or under heavy traffic since the light base is well supported and will hold its elevation if the pavement drops off. Replacing the spacer ring or flange ring with a thinner one allows the light to be lowered to match the pavement.

If you expect a long delay before the light fixtures are installed, use a steel cover of the strength and dimensions equal to the light fixture in the space left for the fixture.

Lastly, fill the space between the light fixture and the pavement with a soft bituminous sealer, such as P-605. If a hard sealer is specified, use a P-606 sealer compatible with bituplastic materials. Fill the crevasse no higher than the bottom of the flange ring. If the light base assembly has a pavement ring (Figure 11, on page 33) on the flange ring, fill the crevasse up to 1/8 in. from the surface.

**Note:** If a substantial part of the overlay is less than 3 in. thick; if a large number of glue-ins must be scrapped, or if the primary conductors are old, you should probably scrap the glue-ins and follow the procedures described under "Installation In Asphalt Overlays", on page 53.



# Reinstallation in P.C.C. Pavement Overlays

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Preliminary Steps  
Marking Center Points  
Laying the Conduit  
Coring the Pavement  
Placing the Jigs  
Connecting the Light Bases  
Casting the Overlay  
Making the Fixture Flush  
Completing the Installation

If the system will be used as is, replace the light fixtures during paving with a light base extension 1-1/2 in. shorter than the concrete overlay. Proceed then with paving as described in the section entitled "Procedures During Paving, on page 30"

If a conduit system upgrade will replace the glue-in conductors, follow the applicable procedures below before the overlay is applied.

### **Preliminary Steps**

Cut and disconnect the secondary conductors (W) inside the base. (Figure 22A, on page 69) If the glue-in system has a junction box outside the light base, the conductors can be cut at the splice in the junction box.

### **Laying the Conduit**

Carefully cut a chase in the pavement between the light bases and transformer housings. Make the chase 6-in. wide (only 3 in. wide if Magnesium Phosphate cement is used) and 1 in. deeper than the conductor opening does.

Next, drill a hole into the side of the glue-in shallow base close to the bottom to connect a 1-in. diameter conduit, either steel or PVC, to the base. A 1 in. diameter conduit is adequate for the secondary conductors; insert this into the base. The conduit is supported in the chase.

A 3/4 in. plywood cover mounted by a mud plate comprise the light base assembly when fastened to a light base extension totaling 1-1/2 in. shorter than the thickness of the overlay. Provide a thin layer of RTV 118 between the base and extension. Encapsulate the conduit in the chase with P.C.C. or Magnesium Phosphate concrete. Make the concrete flush with the surrounding pavement.

The system is now, ready for the overlay paving.

### **Removing Old Bases**

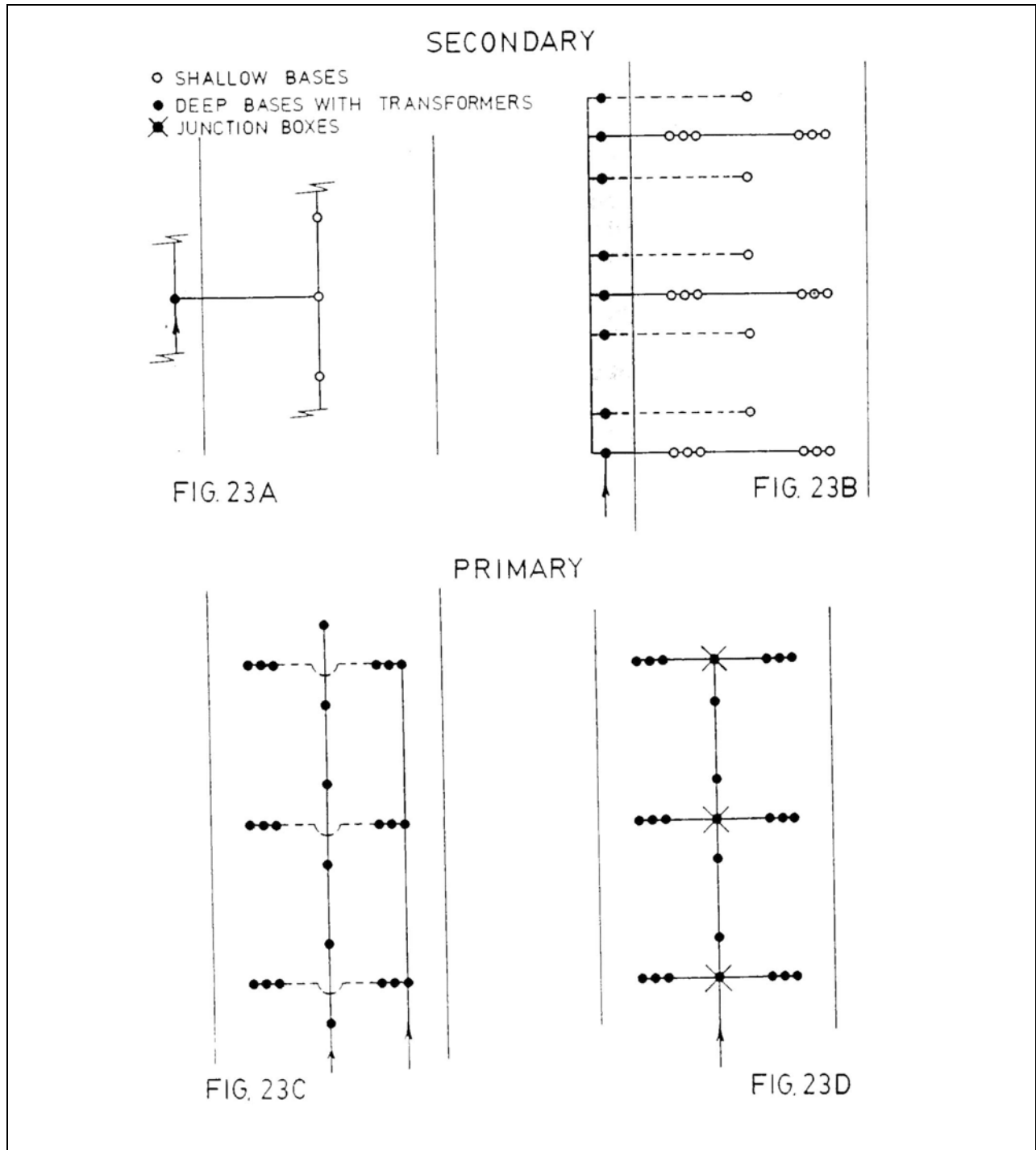
Do not use loose glue-in type bases. If they are not tightly fastened in the pavement, replace them with a one-piece light base (Figure 20, on page 79) before the chases are poured.

Core the loose glue-in type bases out of the pavement with a core drill 12-in. larger in diameter than the bases being replaced (or just 4 in. larger if Magnesium Phosphate concrete is being used). The new light base is supplied with a 5/8 in. plywood cover and a 1/8 in. mud plate.

Install the conduits in the same pattern as that used in the original glue-in system. (Figure 23A or B, on page 78) Connect the 1-in. conduits to the transformer housings near the edge of the pavement where the secondary conductors will be connected to the isolating transformer.

## **Marking the Center Points**

The surveyor will mark all center points of inset lights and will set elevations for the finished pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will mark the center point of the light location on the centerline of the light beam. If the light beam will be at an angle to the centerline, he will mark the center of the light fixture and also locate two points that lie 6 feet on each side of the center point, on a line through the centerpoint and perpendicular to the centerline of the light beam. (See Figure 20, on page 79)

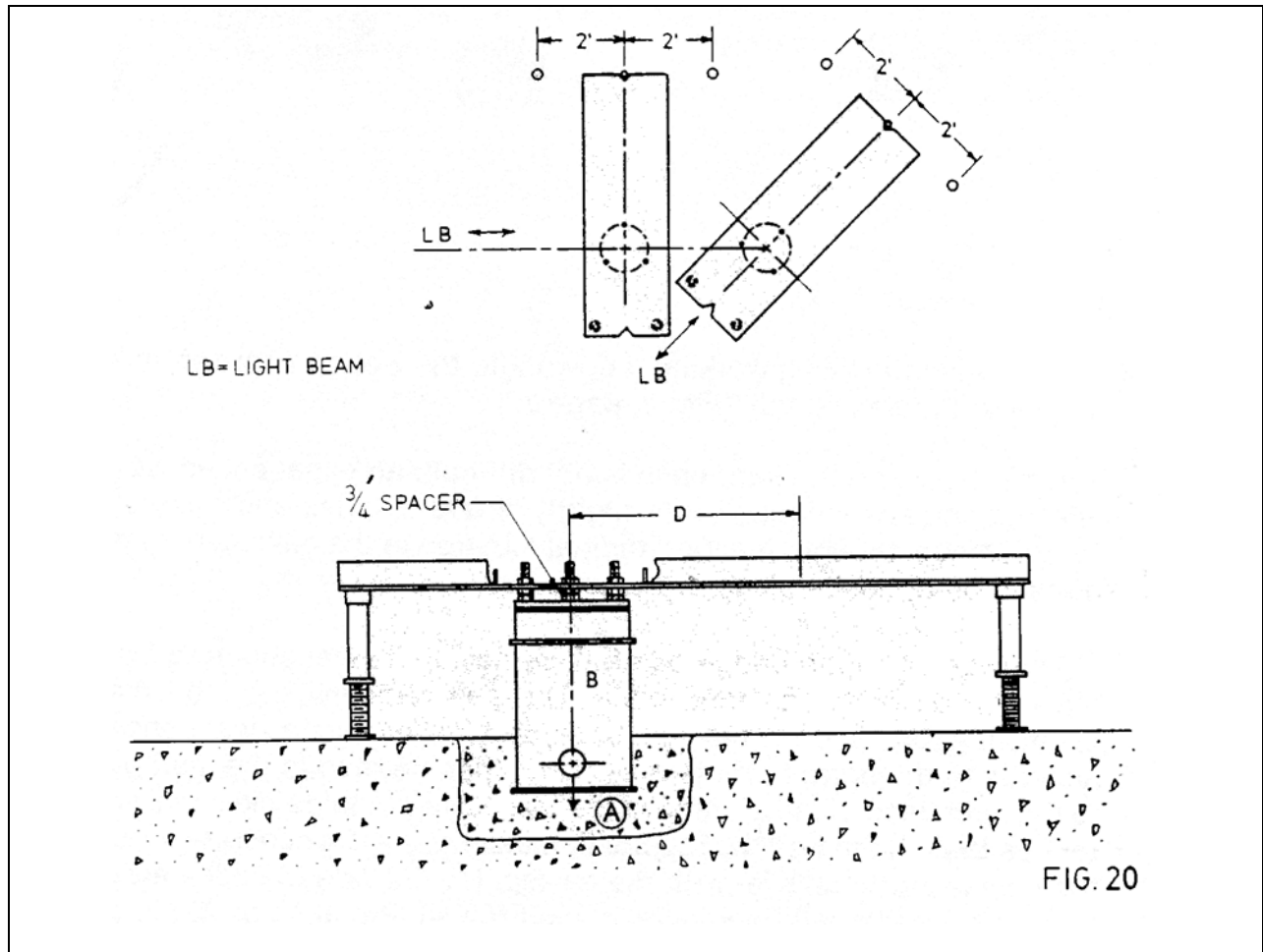


### Placing the Jigs

The jig (Figure 6B, on page 27), with the light base assembly attached, straddles the excavation and is supported by four adjustable legs. (Figure 20, on page 79) The surveyor can line up the jig(s) by sighting a transit through the gunsights on the jig's sides to locate the line through the center point of the light and then chain the distance between lights as shown on the drawings. For radial locations, locate the light's position by using a wire through the two points

perpendicular to the light beam and the gunsights on the ends of the jig. These lines are on a line through the center point of the bolt circle in the holding plate to which the light base is attached. Encapsulate the base up to the level of the old pavement.

**Note:** Once the jigs are correctly placed, use sandbags to keep them from moving. The mud plates of the replacement bases and the extensions bolted to the glue-in bases should be at the same elevation now: 1-1/2 in. below the estimated elevation of the overlay's surface.



### Procedures during Paving

When the replacement bases and the extensions fastened to the glue-in light bases are ready to be cast in the pavement, remove the plywood cover and bolt only the mud plate to the light base. The paving proceeds normally. A thickness of 1-3/8 in. of wet concrete will cover the light base assembly. During the process, a bridge spanning the paving lane behind the paving train stops at each buried light base. A worker on the bridge directly over the light base inserts a "cookie cutter" (a thin metal hoop slightly larger in diameter than the base and about 5 in. high) around the base, working it down into the wet concrete at least 1 in. below the base's top. (See Figure 8, on page 31)

**Note:** Locating the light base is not difficult: an experienced worker will recognize its location by its slightly different appearance. If needed for reference, though, the longitudinal location in the pavement can be marked on opposite sides of the lane.

The worker on the bridge carefully removes the wet concrete inside the hoop down to the mud plate. He then removes the mud plate, cleans the top flange of the light base and makes sure no wet concrete adheres to the bottom of the mud plate, then he rebolts the mud plate to the light base. If the surface of the wet paving outside the cookie cutter has been disturbed, he repairs it, making sure the concrete outside the cookie cutter is level with the paving. He finishes the edge around the cookie cutter with a special curved trowel (See Figure 9, on page 30) to provide a radius around the edge of the opening.

**Note:** Wiping the cookie cutter with a light vegetable oil before inserting them makes their removal later on easier.

### **Making the Fixture Flush**

When the concrete has set, remove the cookie cutters. The actual depth of the concrete is measured between the top of the paving and the mud plate. If the pavement is the specified thickness, insert a spacer ring 3/4-in. thick. This will leave a space the thickness of the light from the surface. If the pavement is thicker than specified, use a thicker spacer ring. If it is thinner than specified, use a thinner spacer ring to bring the light fixture flush with the surface.

On a "dry system," use a flange ring instead of a spacer ring. If the thickness of the concrete above the mud plate is more than 1-1/2 in., use a spacer ring of proper thickness together with the flange ring to make the light flush with the surface. If the concrete above the mud plate is less than 1-1/2 in. thick, use a thinner flange ring.

The thinnest flange ring possible is 1/4 in. thick. If this is too thick, the paver has missed the thickness by 1/2 in., which usually justifies rejecting the paving. If accepted and the installation is a "dry system," see the chapter titled Remedial Methods, on page 101. The thinnest spacer ring is 1/16 in. If this is too thick, the pavement is under-thick by 11/16 in. If Accepted, (Hardly Possible!), see Remedial Methods.

Spacer rings starting at 1/16 in. and flange rings starting at 1/4 in. can be used in increments of 1/16 in. You can combine spacer rings of different thickness, just as you can combine spacer and flange rings. (See Figure 11, on page 33) However, avoid using more than three rings if each is less than 3/8 in. thick. Never use more than two rings to make adjustments under 3/8 in.

### **Completing the Installation**

Attach the light fixture to the light base with stainless steel bolts and anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180-in. lbs.). Provide a thin layer of leveling silicone sealer between the spacer or flange ring and the light base flange. As a temporary cover, use the plywood cover supplied with the light base. Position it on top of the spacer or flange ring. But if you expect a long delay before the light fixture is installed,



use a steel cover of strength and dimensions equal to the light fixture, as well as any adjustment ring necessary.

**Note:** If numerous glue-in bases are loose or suspect, or if the primary conductors are old, it may be wise to scrap the glue-ins and follow the procedures under Installation in Portland Cement Concrete Overlays, on page 59.



# **Installation of Inset Lights in Rebuilt Sections of Runways, Taxiways and Aprons**

Sometimes only portions of paved areas require corrective or additional construction. Examples of this kind of paving are:

- replacing and repairing failing impact areas or runways
- lengthening runways and taxiways incapable of taking anticipated heavier loading
- adding to the apron at new terminal and service areas
- increasing fillets on taxiway turns

If any of these areas now have or will have inset lights installed, the steps usually involve a combination of new or overlay procedures covered earlier in this manual. For instance, if a failing runway will have a center keel placed to remedy a section now in poor shape, the lights in the keel section will be installed as described in the chapters on New Pavement.

Similarly, transition areas to untouched portions might have some overlay to meet the differences in grade. Areas already equipped with inset lights might have surface upgrades as part of a project. In such a case, the section rebuilt will follow the procedures described under Reinstallation of Inset Lights in Overlaid Pavements, on page 65.

# **Installation of Inset Lights in Pavements not to be Overlaid**

Successful installation of inset lights in existing pavement requires following certain procedures carefully. This is particularly important when the need for inset lights exists and the airport's pavement is in good condition. Before methods were developed for installing a conduit inset-light system in existing pavement, the cost of installing one was excessive—unless new construction or overlay paving was also involved. This is why planning and foresight are critical: if new pavement or overlay paving is necessary, it is wise to consider installing the interface for inset lights even if the real need for them is years away. This sort of planning can eliminate duplicate downtime and installation cost as well as eliminates cutting into the new pavement when the system is installed in the future.

Installing a conduit inset-light system in existing pavement involves many of the techniques developed for new and overlay pavements. Still, certain important differences must be observed and these are described next.

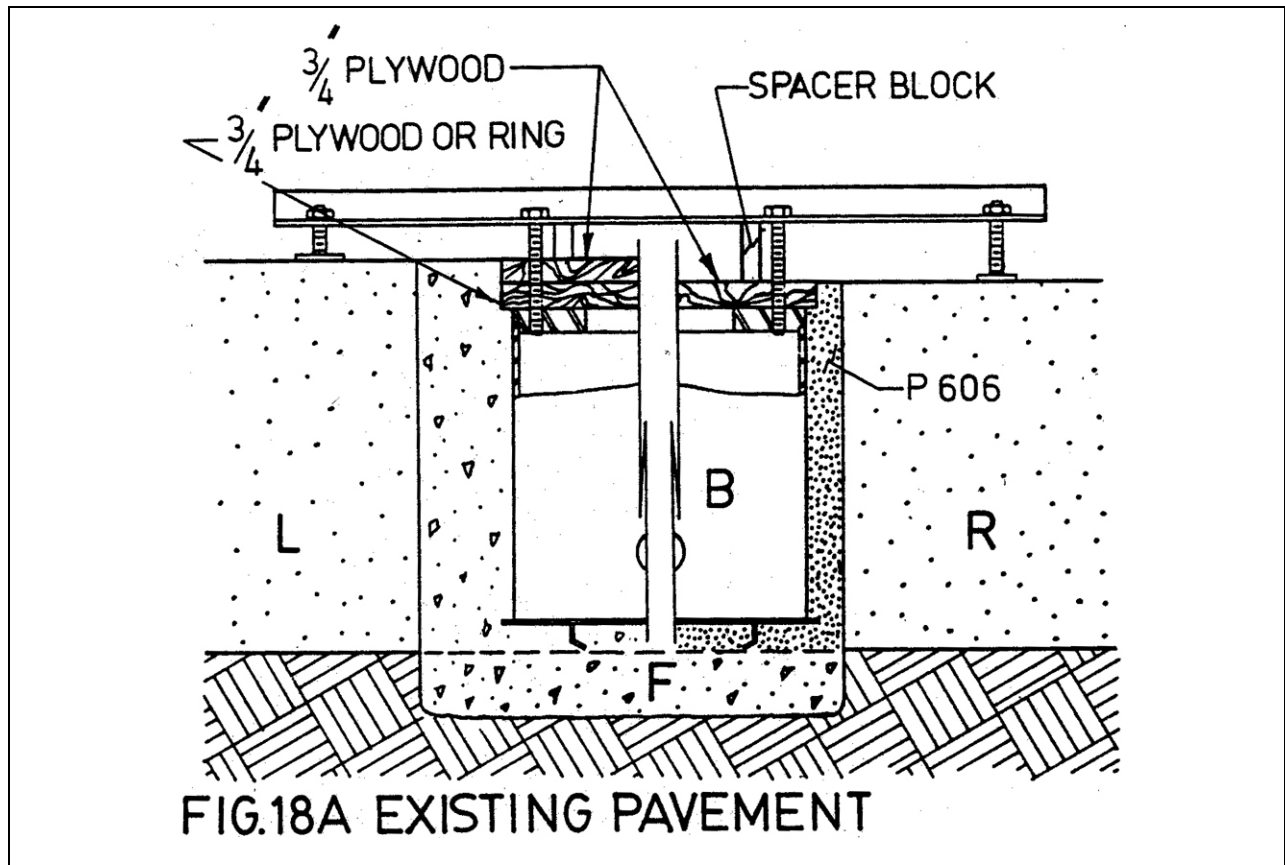
# **Installation in Asphalt Pavement (Not to be Overlaid)**

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Marking Center Points  
Coring the Pavement  
Achieving the Right Density  
Placing the Jigs  
Connecting the Light Bases  
Completing the Installation

### Marking Center Points

The surveyor will mark all center points of inset lights on the pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will mark the center point of the light's location on the centerline of the light beam. If the light beam will be at an angle to the centerline, he will mark the center of the light fixture and will also locate two points that lie 4 feet on each side of the center point, on a line through the center point and perpendicular to the centerline of the light beam. (See Figure 18A,L, below.)





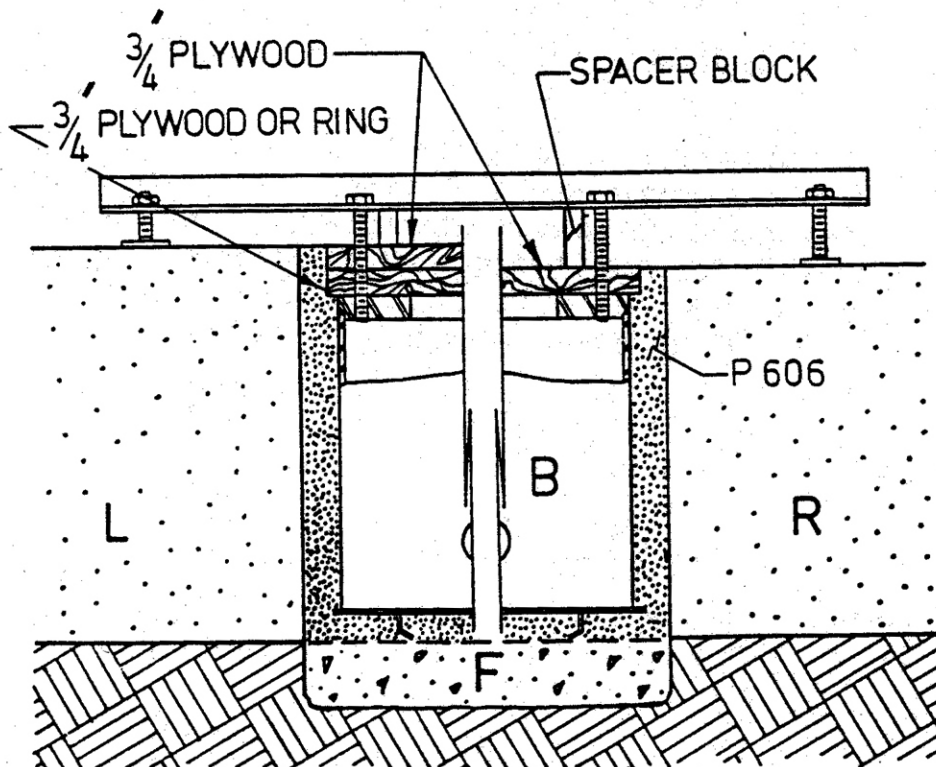
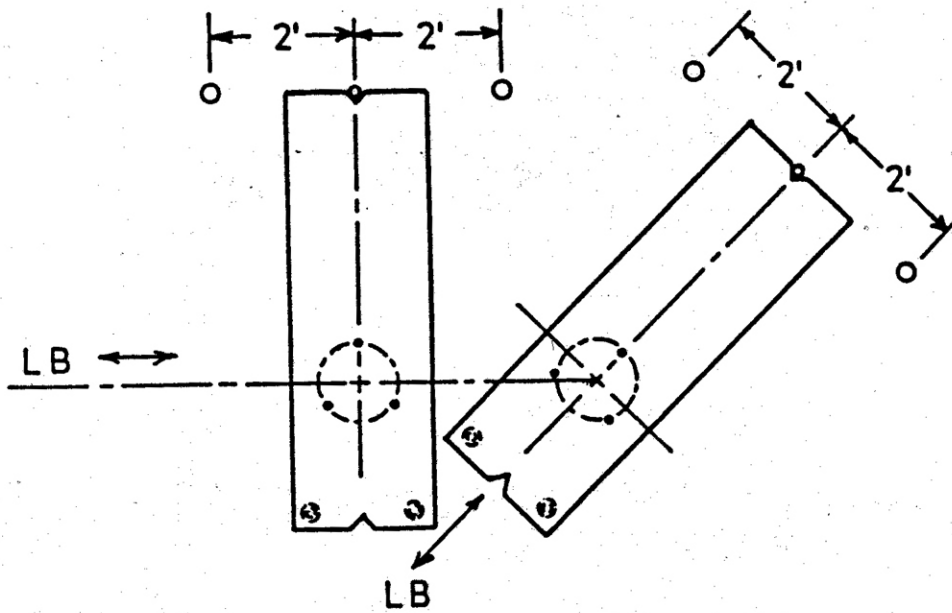


FIG.18B EXISTING PAVEMENT

## **Coring the Pavement**

At the center point of each light, core a hole 1/2-in. larger than the diameter of the light base and 1/2 in. deeper than the light base assembly. To position the core drill, use a template of the proper diameter. Locate the center point of the template on the center point of the light and consistent with the perimeter marked on the pavement. Cut a chase 6-in. wide and 1/2 in. deeper than the cored hole for the light base through the center in the pavement. Carefully remove all loose materials.

Light bases may have any number of entrances depending on branches in the conduit system. Place all conduit branches shown on the plans (including drainage stubs) that may be paved over before those with light bases.

## **Achieving the Right Density**

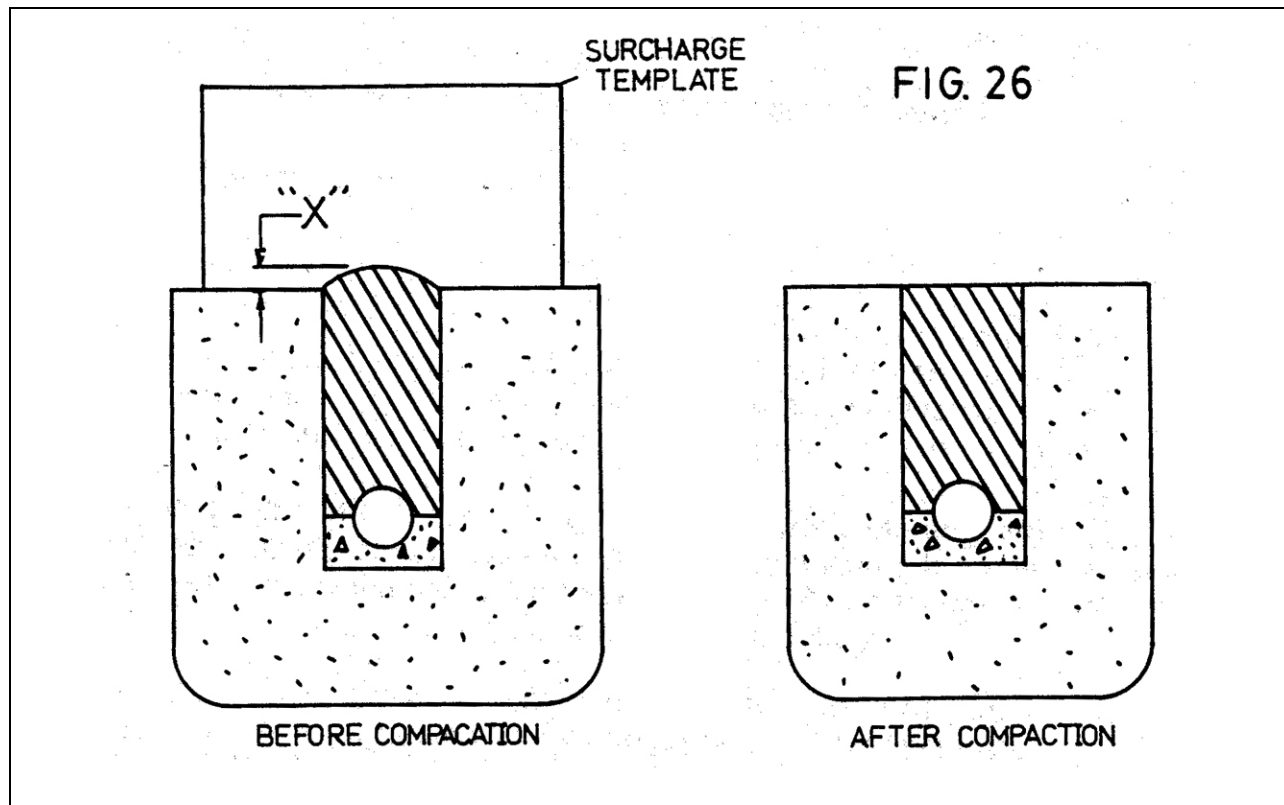
The asphalt in the chase must have the same density as the pavement surrounding it. The installer must use empirical, on-the-spot methods to determine how best to achieve proper density.

First, prepare a short test section of chase that has the dimensions shown on the drawings for the installation. In the chase, a section of conduit supported 3 in. from the bottom of the chase, is encapsulated with P.C.C. to a minimum of half its diameter.

By trial and error, using a mix with a maximum 3/8-in. diameter aggregate, establish the amount of asphalt surcharge needed to meet the compaction criteria. Determine compaction criteria by Nuclear Compaction Tests matching densities of the contiguous pavement and the filled chase.

When the density meets the criteria, prepare a template of the actual surcharge. Use this template at points along the installation to insure a uniform, approved density. (See Figure 26, on page 91)

**Note:** Do not use PVC or other materials subject to softening under high temperatures and compactive effort. The only exception occurs when the chase is deep enough to allow at least 2 in. of concrete over the top of the conduit and also to leave 3 in. minimum depth of asphalt on top of the concrete in the chase.



### Placing the Jigs

The light-base assembly consists of a light base, a 3/4 in. plywood cover and either a 3/4 in. flange ring (dry system) or a 3/4 in. spacer ring (wet system). In wet systems, drainage stubs should be provided. (See Figure 1A&B, on page 17)

Lay a jig (See Figure 6A, on page 27) on the pavement over the cored hole. (See Figure 18A, on page 88) Suspend the light-base assembly, from the holding plate of the jig down into the hole. The light base assembly consists of the base, a 3/4 in. thick plywood cover, plus either an extra plywood cover, or a 3/4 in. thick steel construction ring, or a flange ring if it will be used in a "dry system". If designed as a wet system, use only 3/4-in. plywood. The light base assembly should be level with the surface of the pavement. The light base should be at least 8 in. high to have room for the isolating transformer and cable connectors.

For lights whose beams will be parallel to the centerline, the surveyor can line up the jig(s) by sighting a transit through the gun-sights on the jig's sides to locate the line through the light's center point and then chain the distance between lights as shown on the drawings. Usually, if they are in a row, a number of light bases are located at one time.

For lights whose light beams are at an angle to the center line, the surveyor can locate the center point of the light by using a wire through the two points perpendicular to the light beam and the gunsights on the ends of the jig.

After placing the light bases, use sandbags to keep the jigs from moving.

### Connecting the Light Bases

Make all connections to the light base now. If the light base has a threaded hub, use a nipple and coupling to make the connection to the light base inside the cored hole. If the conduit is rigid, use a waterproof, flexible coupling. If the light base has a grommet opening, insert the conduit into the grommet to make the connection. The depth of penetration into the light base should be about 3/4 in. if the conduit is steel, or 1-1/4 in. if the conduit is PVC.

Pour P-606 material (certified compatible with bituplastic materials) between the base and the cored hole to fasten the light bases into the pavement. The P-606 should be no higher than the top of the light base flange. Take care to assure that the epoxy completely fills the void around and under the light base and around the anti-rotation and anti-uptift anchors on the bottom. (See Figure 18A,R, on page 88)

**Note:** To keep the epoxy out of the chase, build a dam across the chase and around the conduit at the light base.

Next, connect conduit (usually 2 in. diameter) laid in the chase after removing the dams when the epoxy around the base has set. Support the conduit in a fill of P.C.C. (or of Magnesium Phosphate concrete) as described above. A minimum of 3 in. of asphalt over the concrete in the chase is necessary, so leave at least 3 in. of the chase unfilled.

**Note:** Magnesium Phosphate concrete will develop a compressive strength of over 2000 psi in 45 minutes and over 6000 psi in 24 hours.

When the epoxy encapsulation of the base has set properly, remove the jigs. Then pave the chase following the procedures set by the compaction test.

### Completing the Installation

Figure 24A, on page 98, shows the installation of the light fixtures. If the installation will be a "dry system," remove the plywood and spacers. Place a flange ring (R) on the light-base flange. Apply a thin layer of RTV 118 silicone sealer between them. Insert an "o" ring in the groove of the flange ring.

If the installation will be a "wet system," place a spacer ring (R) on the light base flange with a thin layer of RTV silicone adhesive between the ring and the flange. Bolt the light fixture on top of the ring to the light base, using anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180-in. lbs.).

**Important:** Using the ring allows you to lower the light fixture in the future. This may be required if the pavement slumps in warm temperatures or under heavy traffic. Since the light base is well supported and will hold its elevation if the pavement drops off, replacing the spacer

ring or flange ring with a thinner one allows you to lower the light, thereby adapting it to the pavement.

If you expect a long delay before the light fixtures are installed, use a steel cover of equal strength and dimensions to the light fixture in the space left for the fixture. (See Figure 24B, on page 99)



# **Installation in Concrete Pavement (Not to be Overlaid)**

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Marking Center Points  
Cutting the Pavement  
Placing the Jigs  
Connecting the Light Bases  
Pouring the Concrete  
Completing the Installation

## Marking Center Points

The surveyor will mark all center points of inset lights on the pavement. The light beam of the light may be on a line parallel with the centerline, or it may be at an angle. If the light beam will be parallel with the centerline, the surveyor will mark the center point of the light's location on the centerline of the light beam. If the light beam will be at an angle to the centerline, he will mark the center of the light fixture and will also locate two points that lie 4 feet on each side of the center point, on a line through the center point and perpendicular to the centerline of the light beam. (Figure 25A, on page 97)

## Cutting the Pavement

Cut a chase as deep as the light base in the pavement between the light bases. Make this cut 6-in. wide if P.C.C. is being used, or 2-in. larger than the diameter of the conduit if Magnesium Phosphate concrete is being used. Carefully remove all loose materials.

Next, core a hole at the center point of each light. If you are using P.C.C., make the hole 12-in. larger than the diameter of the light base. If you are using Magnesium Phosphate concrete, make the hole 2-in. larger than the light base's diameter.

If any doubt about the pavement's bearing ability exists, dig the hole 6-in. deeper to allow for a P.C.C. pad. (F)

Light bases may have any number of entrances depending on branches in the conduit system.

## Placing the Jigs

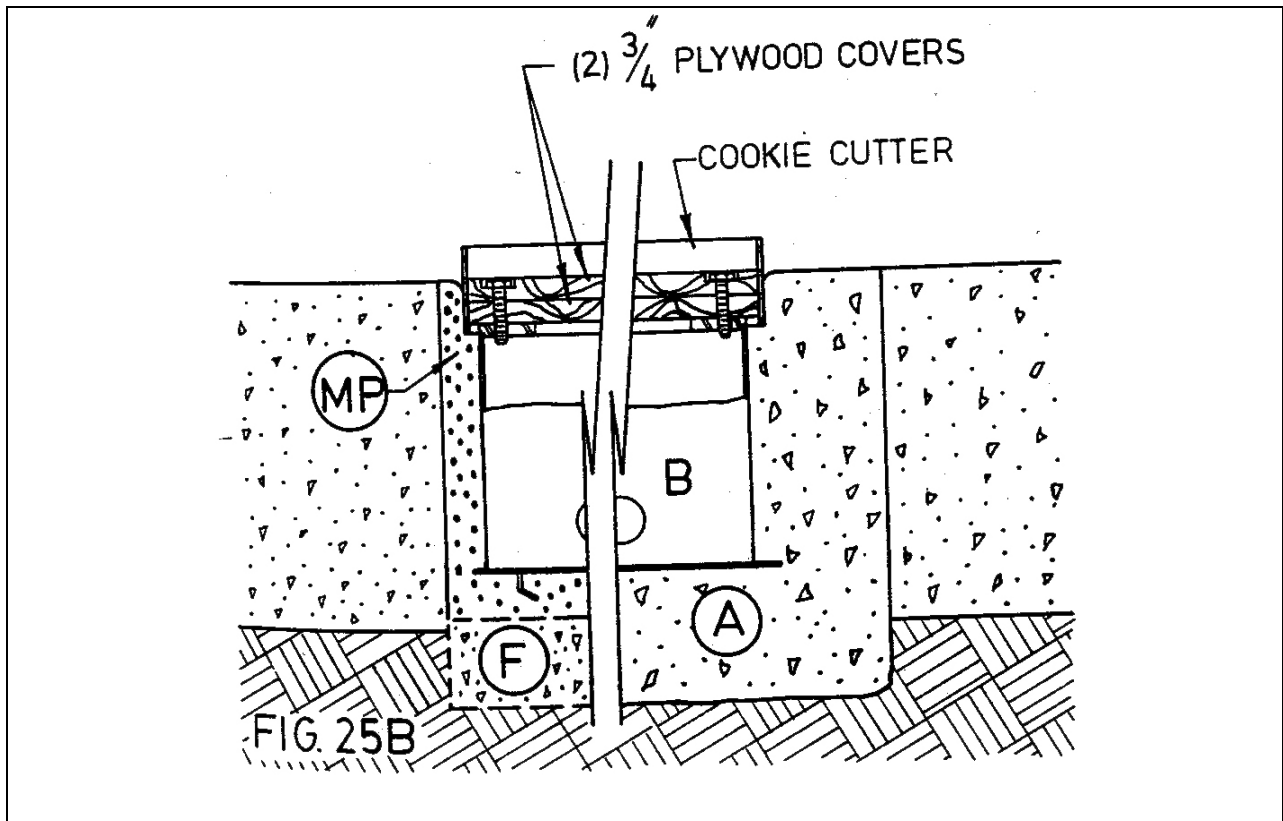
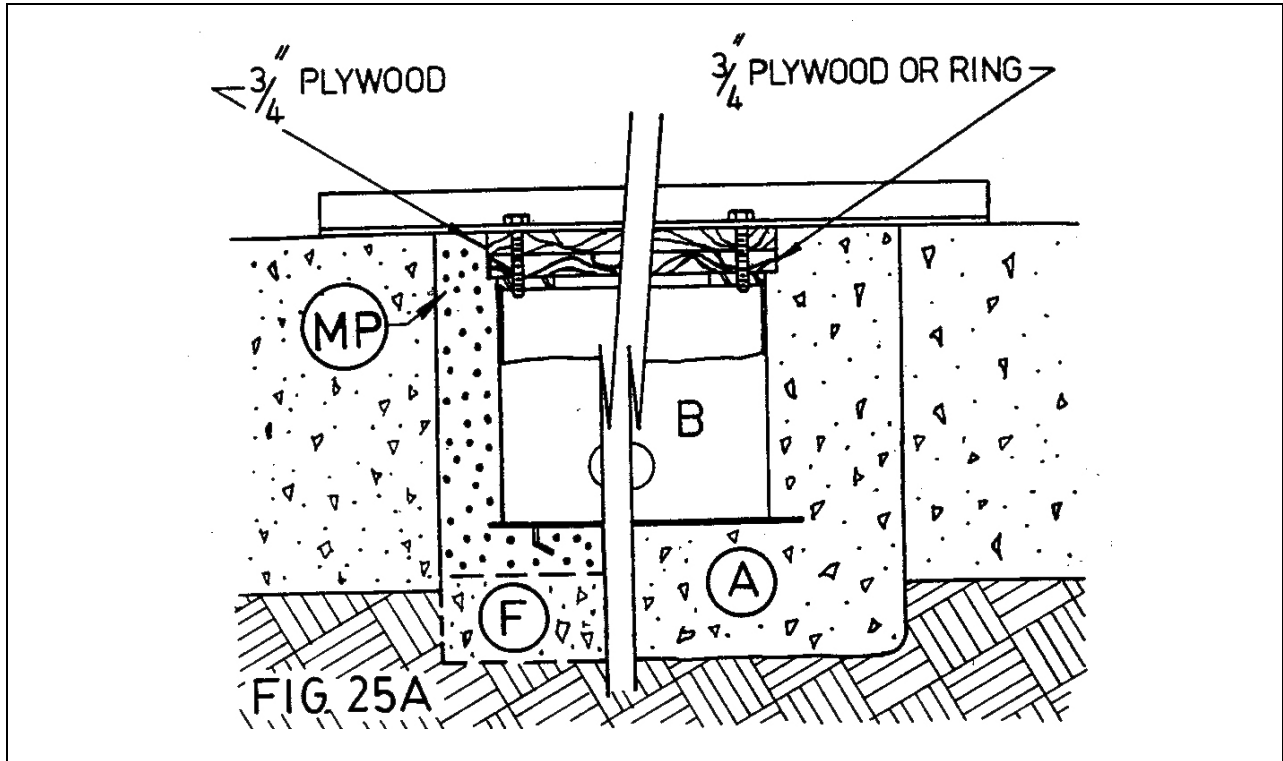
Suspend the light base assembly from the holding plate of the jig, which rests on the pavement. (Figure 6A, on page 27.) The surveyor can line up the jig(s) by sighting a transit through the gunsights on the jig's sides to locate the line through the light's center point. He can then chain the distance between lights as shown on the drawings. Usually, a number of light bases are located at one time.

For lights whose light beams are at an angle to the centerline, the light's position can be located by using a wire through the two points perpendicular to the light beam and the gunsights on the ends of the jig.

**Note:** The light base assembly for a dry system consists of the base, a 3/4-in. thick plywood cover and a construction ring or extra plywood cover. The base has an oversized bottom plate that anchors it in the encapsulation.

Suspend the light base assembly from the holding plate of the jig down into the cored hole. Adjust so that the top of the plywood cover is level with the pavement's surface.





### Connecting the Light Bases

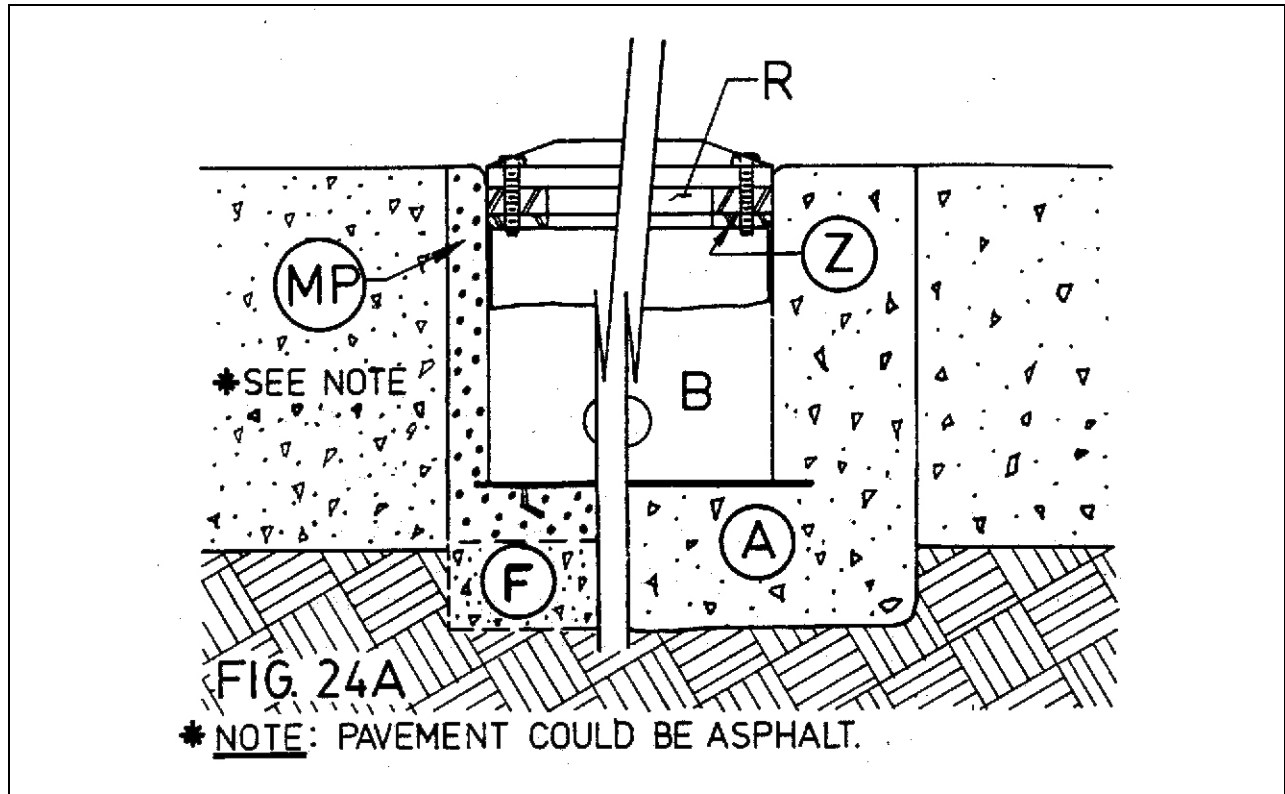
Make all connections to the light base now. If it has a threaded hub, use a nipple and coupling to make the connection to the light base inside the hole. If the conduit is rigid, use a waterproof, flexible coupling. If the light base has a grommet opening, insert the conduit into the grommet to make the connection. PVC conduit should penetrate the light base 1-1/4 in. Rigid conduit should penetrate 3/4 in.

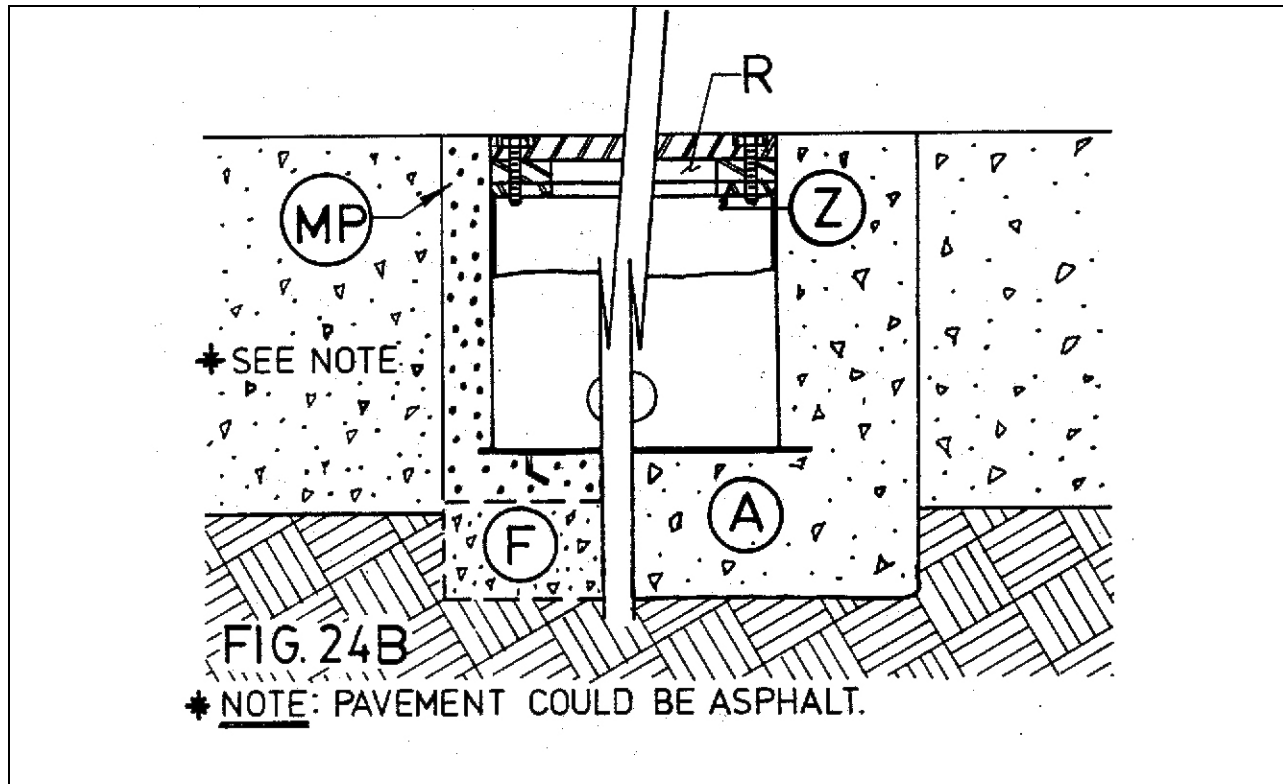
Before pouring the encapsulating concrete, place sandbags to keep the jigs from moving.

### Pouring the Concrete

The system is now ready to be placed. (See Figure 25B, on page 97) Lay conduit (usually 2-in. diameter) in the chase 3 in. from the bottom. Then encapsulate the conduit in P.C.C. or a Magnesium Phosphate quick-setting concrete. (The latter will develop a compressive strength of over 2000-psi in 45 minutes.)

Take care to assure that the concrete flows under and around the bottom of the light base and conduit. Light bases used in this type of installation have anti-rotation and anti-uplift anchors on their bottoms—be sure the concrete flows around the anchors before it hardens.





Now work a "cookie cutter" (See Figure 8, on page 30) down into the wet concrete at least 1 in. below the top of the light base.

**Note:** Wiping the cookie cutter with a light vegetable oil before inserting it makes its removal later on easier.

Remove the plywood and clean the flange of the light base. If a flange ring is used, place it on the light base flange with a thin layer of silicone sealer such as RTV 118 between ring and flange. Clean the plywood and then bolt it to the light base (with the flange ring, if a dry system is specified).

If the surface outside the "cookie cutter" has been disturbed, repair it. Finish the pavement edge around the fixture with a special curved trowel to provide a radius around the edge. (Figure 9, on page 30) Lastly, make sure the encapsulating cement is level with the surface of the existing pavement.

### Completing the Installation

When the concrete has hardened, remove the "cookie cutter" and the plywood. Insert an "o" ring in the groove of the flange ring. Then bolt the light to the light base using anti-rotational washers at a torque recommended by the light base's manufacturer (usually 180-in. lbs.).

If the system will be a "wet system," bolt the light to the top flange of the light base with stainless steel bolts and anti-rotational washers at a torque recommended by the manufacturer of the light base (usually 180-in. lbs.).

# Remedial Methods

- 
1. Missed Elevation
  2. Out of Position
  3. Tilted Base
  4. Out of Azimuth
  5. Stripped or Broken Bolts
  6. Interfacing
  7. Short Extensions
  8. Lights Too Dim

Over the past 15 years, monolithic conduit systems have been installed in hundreds of airports—in new pavement, in overlays and in existing pavement. These installations represent well over 100,000 lights. However, by gaining experience and becoming familiar with the techniques involved, the incidence of mistakes and problems are becoming infrequent. Most of these are the result of surveying errors, incompetency of workmen, poor planning and design, unexpected conditions such as unstable subsoil, off-spec paving and use of unsuitable materials. Some light bases have been set off-azimuth, set off-level, or set to incorrect elevation. Various methods have been devised) to remedy these errors without resorting to repaving.

This part of the manual is intended to help you overcome existing problems, miscalculations and assorted difficulties. Covered here are various errors and the remedial steps needed to correct them successfully and at reasonable cost.

## **1. Missed Elevation**

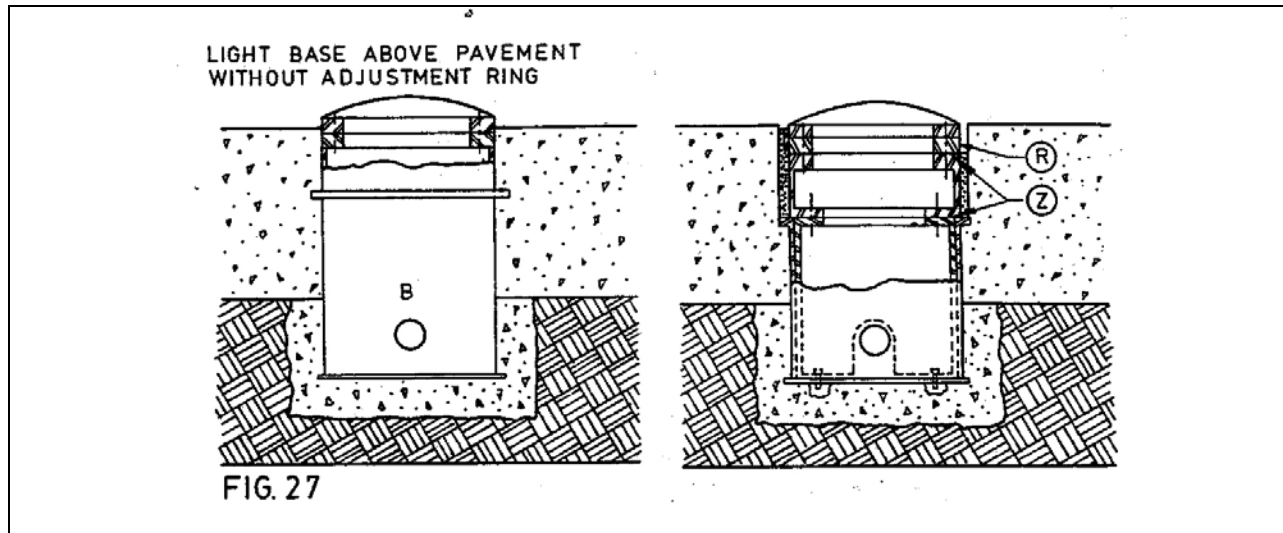
Miselevation is not serious for a light base below the required elevation. Simply using a thicker flange or spacer ring will bring the light to the proper elevation. But if the light base is higher than the pavement when the installation is complete, a tougher problem exists. A light base set too high is serious in rigid pavement because the one-piece base is firmly anchored.

To correct this problem, use an acetylene cutting torch with a scarfing tip to cut off a section of the base's top above the mid-ring. (Figure 27 on page 103) After cutting and discarding the top portion, place a special corrective base (which fits inside the old base) in the remaining bottom section.

The new two-piece corrective base has a smaller outside diameter than the inside diameter of the old base, but the new base has a flange of equal dimensions. It also has openings to allow the conductor cables to enter the old base. The top flange has the bolt holes needed to fasten the light fixture and any spacer or flange rings required.

Secure the bottom of the base as shown in Figure 27, on page 103. Bolt the light and rings to the new top flange using a torque recommended by the manufacturer of the light base (usually 180-in. lbs.).

If the installation is in asphalt pavement, core out the top section and bolt a new top section of the correct height to the bottom section. Then replace the epoxy and light fixture.



## 2. Out of Position

It is possible, especially on high-speed exits, to miss the arced curve of the light line and consequently to have some bases out of position. To correct the problem, core a hole at the proper location to accommodate a light base 3-in. deep. (Figure 28, on page 105) Make this cored hole 1/2-in. larger in diameter than the shallow base and 4 in. deep. Cut a chase to hold a 1-in. steel conduit between the cored hole for the shallow base and the existing, mislocated light base.

The special shallow base will have a 1 in. hub oriented to the bolt circle (and thus to the light beam direction) so as to face the mislocated light base. With a 1 in. diameter conduit laid in a chase, connect the shallow base to a 1 in. grommet placed in a hole drilled in the side of the mislocated base where it meets the chase.

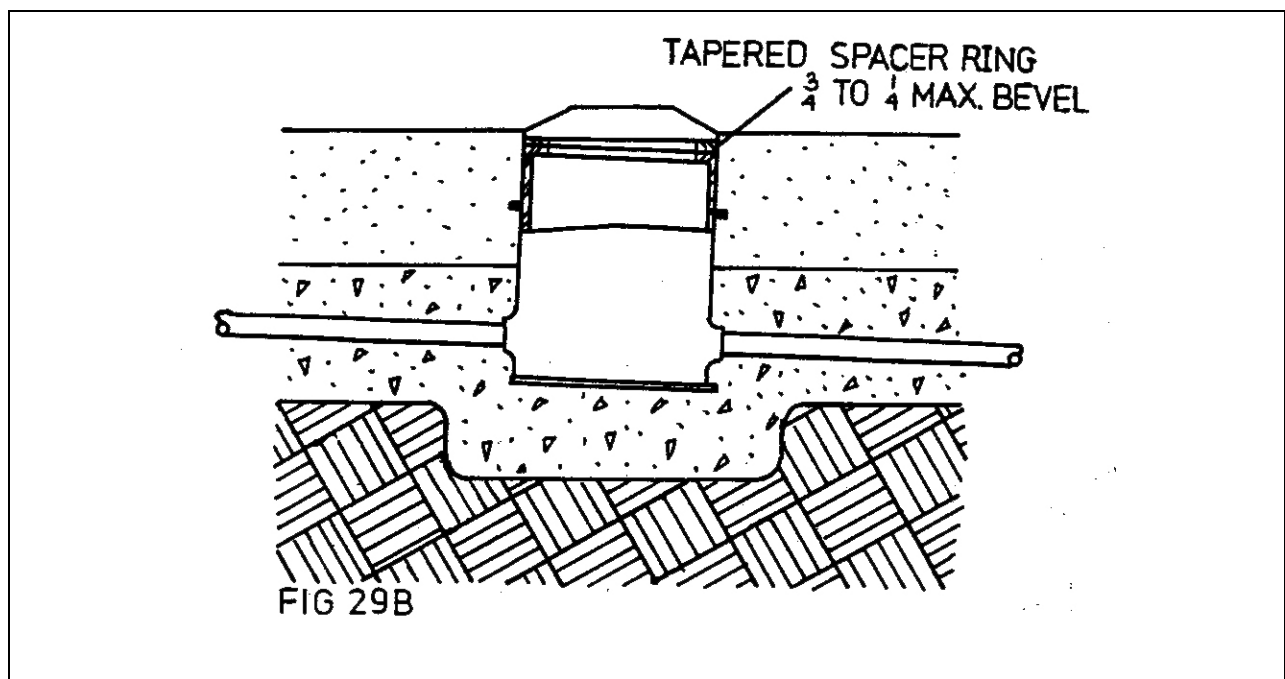
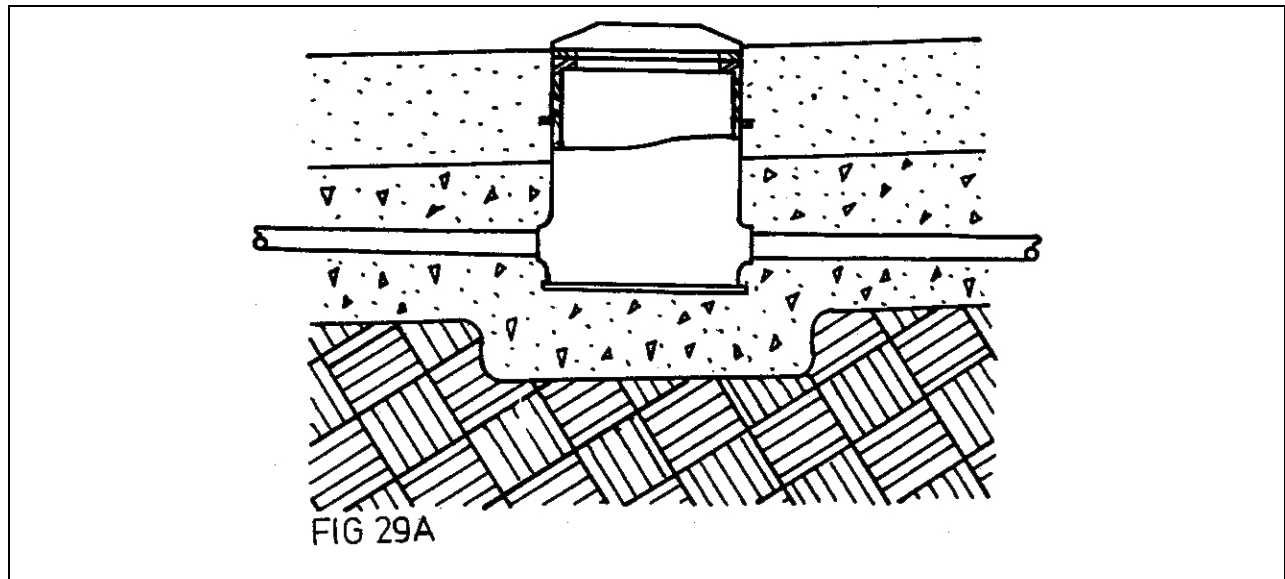
Use a jig to hold the shallow base to the right azimuth and elevation. Using an epoxy or Magnesium Phosphate concrete, fill the chase level with the pavement's surface. Through secondary leads, connect the isolating transformer in the mislocated base to the light placed in the shallow base.

## 3. Tilted Base

A light base may tilt during the setting or paving process and the top may require leveling. (Figure 29A, on page 104)

Do this by using a tapered spacer ring to offset the angle of tilt, so that a light fastened to it will be level with the surrounding pavement (or horizon, if required). (Figure 29B, on page 104)

If the amount of space above the light base does not permit use of a tapered spacer ring, or if the amount of tilt interferes with bolt clearance, then follow the procedures for Missed Elevation, described on page 102. When you calculate the height of the corrective base, allow enough space for a tapered spacer ring.



#### 4. Out of Azimuth

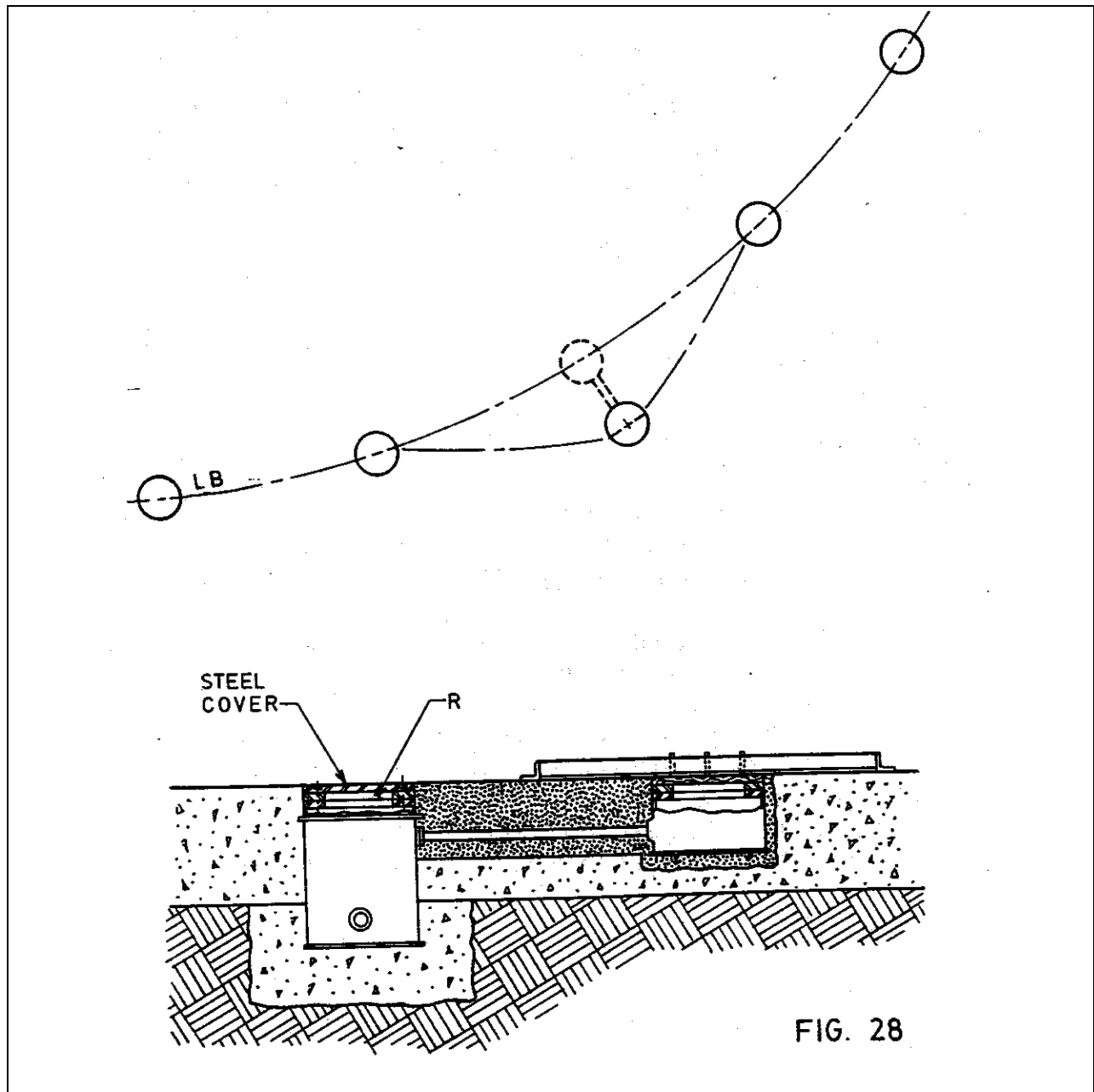
Lights out of tolerance for azimuth can be brought into tolerance if the installation uses a flange or spacer ring at least  $\frac{3}{4}$  in. thick.

To adjust azimuth, discard the ring and replace it by a special remedial azimuth ring of the same thickness. (Figure 30, on page 106) This remedial ring is supplied to compensate for the angular error. The ring, has tapped holes, that hold the light fixture, rotated to compensate for the



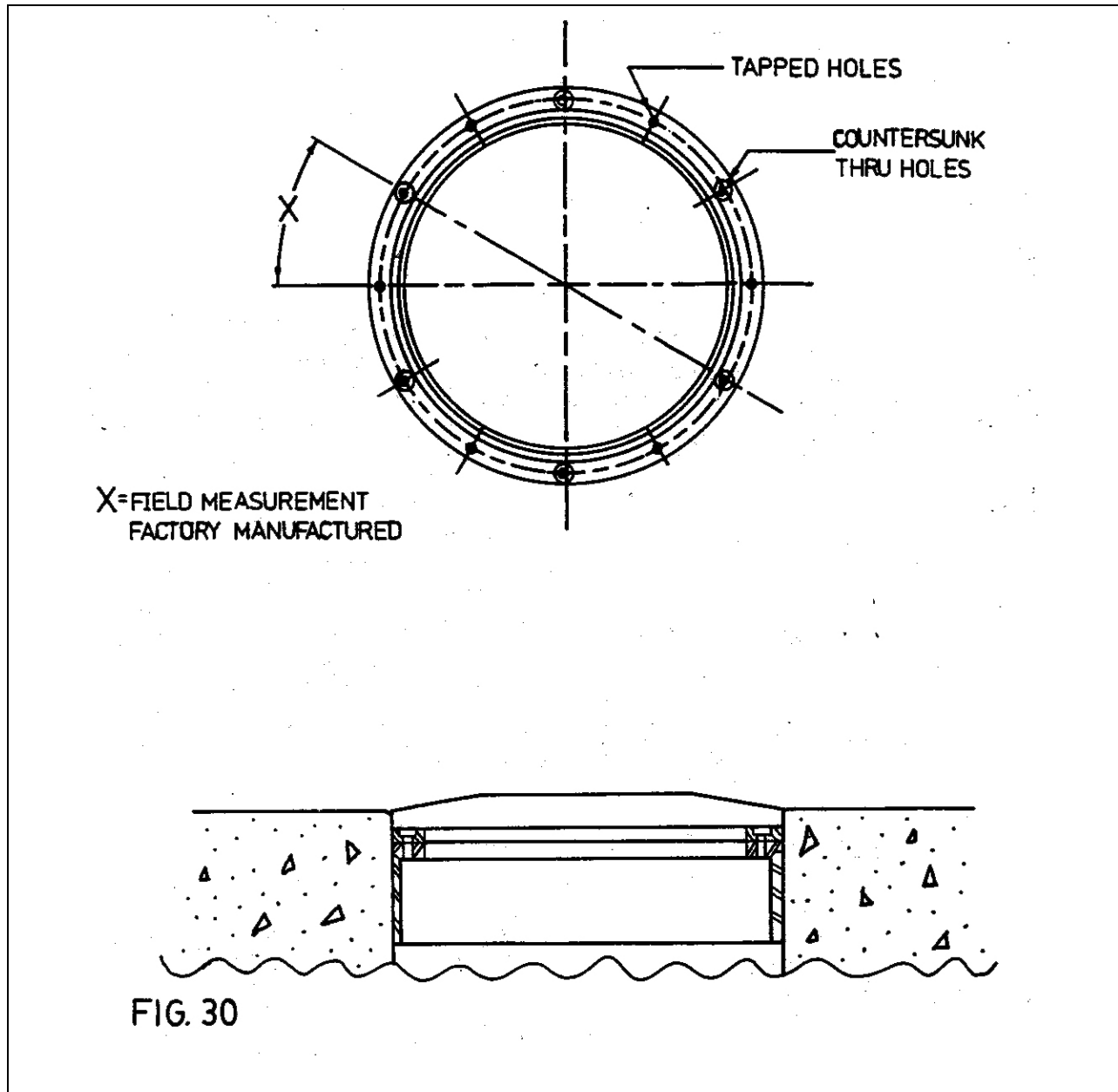
amount of angular error, as well as counterbored holes to allow bolting of the azimuth adjustment ring to the light base.

If the ring being replaced by the azimuth adjustment ring is less than 3/4 in. thick, follow the steps described on page 102, unless the error is more than 2 degrees. For errors over 2 degrees, the new holes will not overlap the old ones. In this case, bore new holes in the top flange of the base and tap them carefully at positions that will bring the light to the proper azimuth. (Stripped or Broken Bolts Section, on page 106) Fill this unused tapped holes with short, stainless steel set screws and seal them with RTV 118 silicone sealer against water leakage.



### 5. Stripped or Broken Bolts

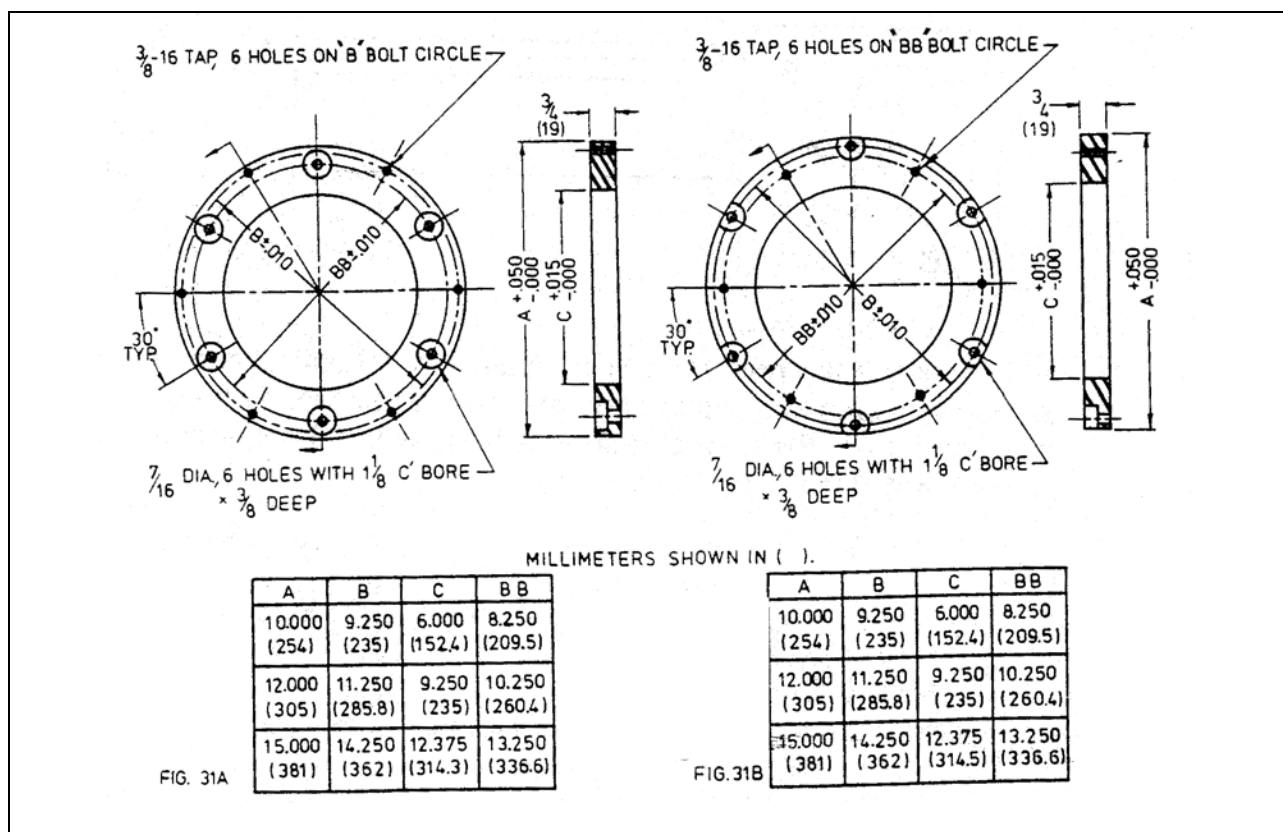
The stainless steel hold-down bolts can be over-torqued, or they can be sheared by impact. Drill out the old threads and bolt with a 7/16-in. drill. Then tap the hole for a 1/2-in. stainless helicoil. When fastened into the new hole, this will provide the means to properly hold a replacement bolt. Seal the helicoil and bolt head with RTV silicone sealer to prevent water leakage.



### 6. Interfacing

The United States and Canadian interface allows interchangeability of all airport lighting systems in both countries. Even so, a given component may be incompatible with another. An example is having a non-load-bearing light base where a load-bearing light base is needed, or vice versa.

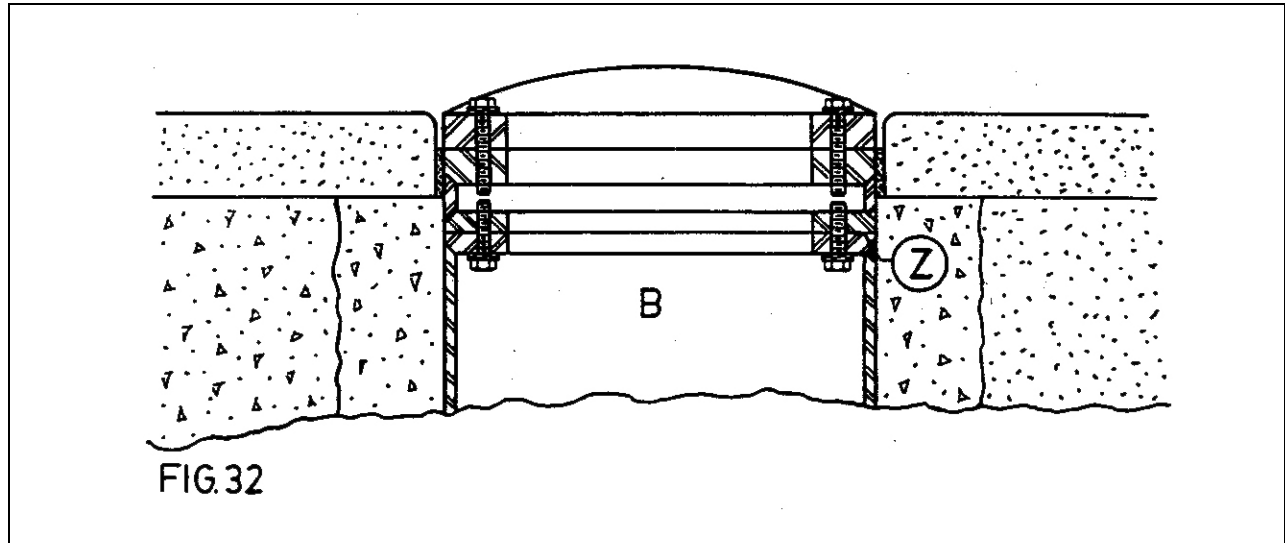
To solve the problem, use an adapter/conversion ring if room for the ring exists. This problem is rare in new construction, but it often surfaces on older pavements during overlays. During a pavement overlay, make the existing light base compatible by matching its bolt pattern and diameter to the pattern on the bottom flange of the light-base extension, which has the new bolt pattern and diameter on the top flange. Adapter rings have both the new and the existing bolt circles, which allows for the exchange of bolt circle and pattern. (Figure 31A,B below)



### 7. Short Extensions

Light base extensions have a minimum height. It is set by the available space inside the extension between the top and bottom flanges to allow the placement of a bolt long enough to make a prop connection.

At times, though, using a shorter extension may be advantageous. When you need to, drill out the threads of the top flange of the light base and order a tapped bottom flange of the extension. Engage the bolts from the bottom. (Figure 32, below)



### 8. Lights Too Dim

If a light seems dim after being energized, check the elevation of the light fixture relative to the pavement's surface. If the pavement interferes with the light beam, the light is too low. Insert a spacer ring thick enough to raise the light level to the surface, or at least closer to the surface.

When a light fixture is tilted, the light may seem dim in part of the required vertical or horizontal angular intensities. The latter is easy to see because the light will appear dim in one direction and normally bright on the diametrically opposite side. Sand, dirt, water, worn rubber and sometimes careless paint marking can cause lights to produce light intensity that is too low.

# Tests for Acceptance and Maintenance

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Light Fixtures  
Light Bases and Hardware  
Pavement

When the installation is complete, inspection and testing must be performed to establish whether the system will function as designed for its expected life.

Inset lights must be both reliable and maintainable. The relatively high cost of installing inset lighting is justified by the improved safety and performance it provides to an airport. However, if it malfunctions or creates hazards through bad performance, it can become extremely costly. If a light that costs X amount of dollars to place, but the amount of visible light is zero, then the true cost of the light is  $X / 0$  or infinite!

If a heavy fixture in a runway becomes loose due to faulty installation or inadequate maintenance and severely damages an aircraft, it obviously is a safety hazard.

Nevertheless, hundreds of installations properly placed and maintained have performed reliably. The items listed below should be examined for compliance with established standards. Important preventative maintenance steps are included as well.

### **Light Fixtures**

Check all inset light fixtures whose function is to give a precise horizontal angular beam direction for their trueness of placement relative to the light beam. Knowing the desired spread and tolerance allowed, check the light by reading an optical spotmeter a known distance directly in front of it. The candela requirement should be within the specified output. Then take readings at a point at right angles to the light beam and at a distance equal to the distance from the light multiplied by the tangent of the specified horizontal beam spread angle on each side of the centerline of the light beam. At these points, the reading should show no diminution of output below the candela tolerance.

The vertical beam angle spread is usually measured by flight checking. The elevation of the light's top edge in reference to the surface is important because lights protruding from the surface can damage a craft tires and nosewheels. (Specifications allow plus or minus 1/16 in.)

Since snowplows can damage the lights, some snow areas allow a tolerance of +0 in. to 1/8 in. Lights set deeper than this will suffer a large drop in light output. The light-beam cone emerging from the light fixture comes to a focus near the juncture of the pavement and fixture. At this point, the cross section of the light beam is little more than 1/4 in. If it impinges on the pavement edge even slightly, light intensity diminishes. A walk or drive in the installation area will reveal lights not installed properly operating at a lower intensity than those which were properly installed.

If a light should be level with the surface but is not, the light beam will be too high on one side and too low on the other. For a bi-directional light, this condition will be noticeable on a ground check. If the light should be level with the horizon but is not, it will show up on the flight check.

Inspect hold-down bolts to see if they are installed with antirotational washers. Also check them with a torque wrench to ensure proper bolt tension. Check fixture surfaces and hardware for

corrosion-resistant surfaces. Make sure the waterproof seal between the fixture body and glass lenses allows no leakage of water. Lights affected by leaks will appear duller than others in the system.

All light fixtures in a given system should be checked for in-line tolerance. Check those in a straight line from front to back and those in a bar from side to side. Assure that lights on a curve are on the specified tangential location.

## **Light Bases and Hardware**

Corrosion is a serious problem confronting the successful operation of an inset lighting system.

While the specifications of metal components allow for extended use, care in installation and maintenance is necessary. Steps against corrosion include the use of nickel-chrome stainless steels, hot-dipped zinc-galvanized coatings, zinc and cadmium plating, chromate washes, enamel finishes, aluminum and rust-resistant structural steel such as Corten.

Similarly, many coatings shield against corrosion only when the surface is unbroken. Careless use of a tool can cause scratches that will eventually corrode. Correct all such missteps immediately, using specified touch-up materials:

Manufacturers spend time and money to package goods that are subject to corrosion—only to find that installers or maintenance personnel unpack the goods prematurely. Leave them packaged until they're needed! Check light bases and accessories used with them for missing coating and signs of corrosion when the bases are put into service. During maintenance, use only the proper recoating material to recoat rusted or damaged bases.

During installation, never allow light bases to have holes cut into them for conduit or other insertions unless the cutting is supervised. Always make sure that if raw edges, caused by cutting corrosion coated steel during installation (not advised without supervision), are recoated with a zinc-rich primer. Check all grounding connections to make sure that they are properly fastened. If a counterpoise system is involved, check connections shown on the drawings. Clean all tappet holes and threaded nipples of foreign materials before use. Examine grommets for proper seating in holes and grip slots. Flanges, metal-to-metal surfaces and "o" ring grooves should be free of dirt and foreign substances.

If any lights show a low intensity on visual inspection, check for dirt and construction debris on lens surfaces and clean thoroughly. Check light fixture elevation in which excess plywood spacers were used during installation, since plywood is no longer made to exact dimensions. Most flexible-pavement installations include many light base extensions of similar sizes. Examine light fixtures carefully for improper elevation due to the intermixing of extensions, top sections; and rings without verifying size, except by a visual glance. Avoid using many thin spacers between the light fixture and the light base. Even a slight waviness in thin spacers will eventually allow movement when loaded and this can produce loss of torque on the bolt and eventual shear. Check "o" ring gaskets for improper seating in the groove. Also check for proper placement and

direction of colored filters in light fixture that specify them. Examine toe in requirements to determine whether they are achieved by placement of the light bases, or whether they are built into the light fixture.

## **Pavement**

Check the pavement for flatness. Visually noting short waves and hollows is fairly easy, but you'll need an optical level to detect longer ones. (Observing the pavement after a rain or after flooding it with water will also expose waves and depressions.) Hollows without openings for the water to drain—known as "fish ponds" are hazardous and in cold climates can cause icy patches. Also, use a long straightedge to check any light fixtures that appear lower than the surrounding surface.

Examine all asphalt pavement in which light bases are located (particularly the pavement above conduit chases) for flushness with the light fixture. Inspect asphalt pavements for density, loose aggregate and reflective cracking. In asphalt pavement, check the drawings and specifications to verify that any encapsulation in which concrete is visible at the surface was deliberately included. Check that the thickness of asphalt pavement over concrete encasements is a minimum of 3 in. thick. Be sure that a minimum of 3 in. of asphalt is placed over concrete encapsulations of light bases and conduit chases.

In all systems, check drainage stubs for blockage at their outlets and within the light bases.



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# Glossary

## A

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### Aggregate, Coarse

Broken rock, stone or gravel graded 1-1/2" to 2" max. diam. and retained on a #4 sieve.

### Aggregate, Fine

Clean sand or rock fines.

### Airborne Guidance

Visual signals used while flying or landing.

### ALS-2 & 3

Approach light system with flashers for category II or III visibility.

### Apron

Paved area contiguous to terminal or where aircraft are parked.

### Azimuth

Direction of the light beam measured in a horizontal plane.

## B

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### Bidirectional Lights

Light fixtures that emit two beams usually, but not necessarily, 180 degrees apart.

## C

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### C T B

Cement-treated base. Soil cement with 1 to 6% cement content depending on strength required, soil and wind conditions.

### Calcium Aluminate Cement

A high early-strength cement capable of reaching a strength equal to 7-day-old Portland Cement in 24 hours.

### Can

Any marker light base.

### Candela

Luminous Intensity.

### Category I

RVR of 2400' with a decision height of 200'.

### Category II

RVR of 1200' with a decision height of 100'.

### Category III

RVR of 0'

### Centerline

A line midway between the edges of a runway, taxiway, etc. However, the centerline defined by a line of lights may be off set 1 1/2 to 2 feet, usually on the side away from the major exits.

### Centerpoint

The exact dimensional or geographical location of a point shown on a drawing.

### Chase

A channel cut or dug in the pavement, sub-base, or subsoil.

### Chord of Bolt Circle

The distance from the center of a hole to the center of the next hole on the same bolt circle. To insure interface between lights, the tolerance is +/- .005"

### Compactive Effort

The work done to increase the density of asphalt paving when installed to meet strength requirements.

### Concrete Ring

A metal vertical ring, usually part of the top flange of the light base or of a flange ring. It is an integral part of the light base with an inside diameter equal to the light base flange.

## D

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### Design Strength

The strength to which airport pavements are designed. Usually 400 psi.

**Displaced Approach Light**

The portion of the approach light systems that terminates within the end boundary of the runway.

**Displaced Threshold**

The line where a displaced approach-light system intersects the runway.

**Drainage Slope**

Slope of the pavement down from the centerline to the edge, for water drainage. Usually 1 to 3%.

**Drainage Stubs**

Conduits used to drain water from the system and not used for electric conductors.

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**E**


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**Elevation**

The horizontal plane of the pavement surface unless otherwise stated.

**Emissivity**

Used in the trade to denote the ratio of the transmitted light through a material to the light incident to it. This should be called transmittance when talking about light.

**Encapsulate**

To use a material to completely surround something.

**Existing Pavement**

A pavement that requires no new surface.

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**F**


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**FAA**

The US Government regulatory body that among other things is responsible for standards and certification of airport lighting.

**Fish Ponds**

Low spot in pavement that can result from unlevel placement of P.C.C. pavement, or low spots in asphalt pavement resulting from wavy installation. The name comes from what appears after a rain.

**Flange**

The top and sometimes the bottom, of a light base to which the light fixture and other equipment is bolted.

**Flat Gasket**

A rubber or synthetic seal placed between the flange of a type I light base. Never used for inset lights.

**Flexible Conduit**

A conduit that is flexible so as to be able to make connections between the light base and the conduit system without strain.

**Flexible Waterproof Coupling**

One of several proprietary couplings available to achieve the connection of the conduit to the light base.

**Flush Light**

An inset light fixture that does not protrude above the pavement surface.

**Fly By Wire**

An aircraft that is controlled by a computer to which input is given by the pilot.

**French Drain**

A cavity in the sub-base filled with coarse broken stones which receives water drained from the light base.

**Friction Grooves**

Saw cuts across a runway to increase the friction between aircraft tires and the pavement and also to reduce "hydroplaning".

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**G**


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**Glue-in**

A term to denote an inset light that is mounted on a shallow light base that is held in an opening in the pavement by epoxy adhesive. The secondary conductors are usually glued into a saw cut in the pavement and are connected to an isolating transformer at the side where it is housed in a type I light base. Conduit, epoxied into a narrow chase connecting the light bases, can be used to protect the conductors.

**Grommet**

A rubber or synthetic seal that can be inserted in an opening in a light base. The grommet has one or more holes that will allow conductor(s) or conduit(s) of the proper diameter to enter the light base in a waterproof manner.

**Ground Guidance**

Visual aids that give information and signals to aircraft on the ground.

**H****Heavy Metal Casting**

A light fixture or components made from high strength cast malleable iron.

**High Intensity Lights**

A light fixture capable of producing candela meeting ICAO and other regulatory minimum intensities for IFR conditions.

**High Speed Exit**

An exit from the runway designed to allow an aircraft to make a turn off at a greater velocity than possible with a right angle turn.

**Hold Bar**

Also called clearance bar. It is a series of lights perpendicular to the centerline of a taxiway to delineate the holding position of an aircraft at the intersection of a runway.

**Horizontal Beam Angle**

The horizontal angular spread of a light beam.

**Horizontal Setting**

The horizontal angular displacement of a light fixture.

**I****ICAO**

The International Civil Aviation Organization, a branch of the UN that sets recommended practices for airport lighting worldwide, among other things related to aviation.

**Impact**

The oblique contact of an aircraft with the paved runway.

**Integrated Installation**

A term used to differentiate between inclusion of an inset light in an asphalt pavement and one monolithically cast in a rigid pavement.

**Interface**

A standard arrangement of light fixture and light base dimensions and connections to allow interchangeability.

**J****Jig**

A contrivance to hold the light base true to ensure the desired azimuth, elevation and level of the light fixture when making conduit connections and pouring the anchor of the light base.

**K****Kerf**

The opening made in the pavement by sawing.

**Lamp**

The source of light of the light fixture when energized.

**Light Bar**

Several-light fixtures in a straight line to give the appearance of a single line of light.

**Light Base Hub**

A threaded fitting that is part of the light base to make connections possible with a conduit or pipe nipple.

**Light Fixture**

The housing, electrical fittings and connectors necessary to hold and protect a lamp.

**Light Fixture Identification**

The designated title for the kind and location of Identification a light fixture as shown on the installation drawings.

**Light Metal Casting**

A casting or die-casting made of aluminum or other thin metal

**Low Intensity Lights**

Elevated lights of low intensity omnidirectional lights averaging 25 candela in white light. Used on small G.A. airfields.

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## M

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**MOT**

The Canadian regulatory body that among other matters is responsible for standards and certification of airport lighting

**Magnesium Phosphate Cement**

A fast setting, high early strength cement capable of reaching the strength of 7 day old Portland Cement in one hour

**Mals**

Medium intensity approach light system.

**Medium Intensity Lights**

Elevated lights of medium intensity. Omnidirectional for runway edge, hold bars and all taxiway lights. Directional for threshold on precision runways.

**Mid Ring**

The ring located 4-1/2 " below the top and around the body of a type II light base to key the light base into the P.C.C. pour.

**Monolithic Paving**

The incorporation of inset lights into the concrete pavement simultaneously with the placement of the latter.

**Mud Plate**

A cover, usually metal, that is placed on the inset light base during the paving process to protect it and facilitate finding it later.

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## N

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**New Pavement**

A pavement constructed on a non-pavement sub-base.

**Non-Load Bearing Base**

A light base that supports a light fixture that is not expected to support an aircraft or ground vehicles.

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## O

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**"O" Ring Gland**

A groove into which an O-ring fits.

**"O" Ring Seal**

A seal effected between two surfaces by the use of an O-ring gasket.

**Omnidirectional Lights**

Light fixtures that have a 360 degree beam spread not necessarily equal in intensity in all directions.

**Overlay Pavement**

A pavement that is constructed on top of a previous pavement.

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## P

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**P 605**

Federal specification for sealing materials.

**P 606**

Federal specification for epoxy or polyester sealing material.

**Pancake Light**

An-early type of glue-in inset light fixture

**Par Lamp**

A lamp unitized with its own reflector and glass lens.

**Paving Lane**

A strip of pavement, usually 25 to 50 feet wide, which is continuously laid for some length.

**Percolation**

A measurement of a material which shows the amount of liquid that will pass through it in a given time.

**Post Tensioned Pavement**

P.C. Concrete pavement that is poured around tubular ducts in which steel tendons are stressed after the concrete has set.

**Pre-Stressed Pavement**

P.C. Concrete pavement that is poured around stressed steel tendons held in place within it until after it has set.

**Primary Circuit**

The high-voltage current supplied to the transformers of the lighting system from the constant current regulators in a series system.

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## Q

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**Quartz-Halogen Lamp**

A lamp with a quartz envelope enclosing an atmosphere of halogen gas.

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## R

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**RAIL Lights**

Runway Approach Identifier Lights that are high intensity strobe approach lights located from 1200 feet from the threshold outward.

**REIL Lights**

Runway End Identifier Lights that are high intensity flasher lights located 40 feet on each side of the threshold.

**Rigid Conduit**

Conduit that is not easily bent, usually made of steel.

**Runway**

The portion of an airport that is used solely for the landing of aircraft.

**RVR**

The Runway Visual Range. The distance from the eye of the pilot to the expected point of touchdown.

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## S

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**Secondary Circuit**

The induced low voltage current from the isolating transformer to the light fixture or other electrical equipment.

**Semi-flush light**

A light fixture inset into the pavement that does not protrude above the surface more than 1/2 inch.

**Shallow Light Base**

A light base that is inset in the pavement and not supported from below. It may, or may not, be connectable to conduit.

**Shoulder**

A paved area on the sides of the usable pavement. It usually is not structurally equal to the pavement, but can be an area that has been denoted as a shoulder by markings on the regular pavement.

**Silicon(e) Seal**

A thin layer of self levelling silicon adhesive to effect an easily removed seal in the future.

**Slope of Inset Light**

The horizontal tilt from level in any direction of a light fixture set in the pavement.

**Spacer Ring**

A steel ring used as a shim to achieve the proper elevation of an inset light fixture.

**Stabilized subsoil**

Subsoil that has been treated to improve its structural characteristics.

**Sub-base**

The structural support for the pavement. Usually compacted broken rock, gravel or stone.

**Subsoil**

The original underlying substance of the pavement.

**Surcharge**

The amount and shape of the bituminous materials positioned for asphalt paving before compaction.

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## T

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**Tack Coat**

A liquid asphaltic material placed beneath each asphalt paving course

**Tapered Ring**

A spacer ring that varies in thickness to allow adjustment to the level of a light fixture that is out-of-level.

**Taxiway**

The portion of an airport that is used solely for ground movement of aircraft between the runway and aprons.

**Threshold**

The end boundaries of a runway.

**Touchdown Zone**

The area of a runway that is expected to be impacted by an aircraft using a precision approach.

**Type I Light Base**

A light base that supports a light fixture that is not expected to be impacted by an aircraft or vehicular traffic.

**Type II Light Base**

A light base that supports a light fixture that is expected to be impacted by an aircraft or vehicular traffic.

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**U**

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**Unidirectional Lights**

Light fixtures whose light beams show in one direction only.

**Vertical Beam Angle**

The vertical angular spread of a light beam The vertical angular displacement of a light fixture

**Vertical Setting**

The Runway Visual Range (RVR).

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**W**

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**Wig Wag Lights**

A pair of lights (usually Yellow) that light alternately.