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ELECTRODELESS FLUORESCENT LAMP

Litek International, Inc.

October 1981

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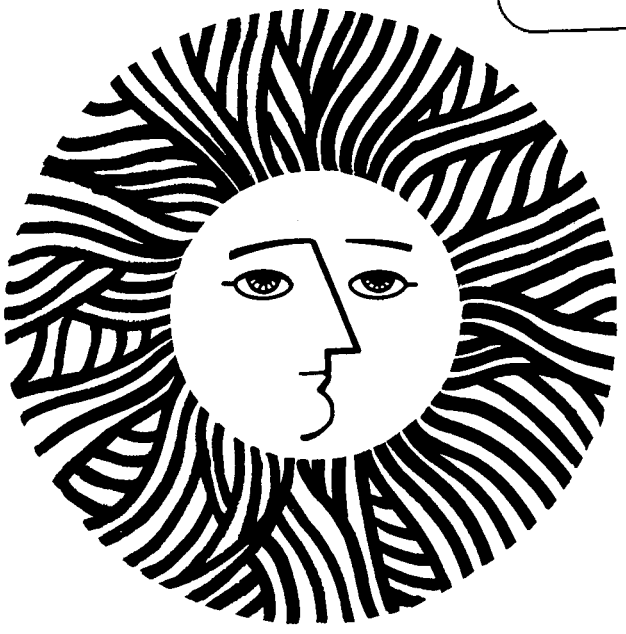

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ELECTRODELESS FLUORESCENT LAMP

FINAL REPORT*

Lighting Systems Research
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720
October 1981

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October 12, 1981

FINAL REPORT

LBL Subcontract 4506310

EXECUTIVE SUMMARY

This program, which was sponsored by the University of California, Lawrence Berkeley Laboratory and the United State Department of Energy, constituted Phase I of a 3 phased procurement which was awarded to Litek International Inc. to develop, test and deliver prototype Energy Efficient Light Bulbs (EELB's). The Litek lamps, delivered to LBL on Sept. 30, 1981, were electrodeless fluorescent light bulbs which employ a solid-state radio frequency electronic driver to excite a mercury vapor gas discharge which, in turn excites a conventional fluorescent phosphor layer to produce visible light.

The electronic driver operates at a fundamental frequency of 13.56 Megahertz, a frequency reserved by the Federal Communications Commission and International Treaties for Industrial, Scientific and Medical (ISM) Equipment.

The Phase I Litek lamps produced in excess of 1500 lumens at initial efficiencies of 50 lumens per watt or greater. However, with slight modifications to the overall systems design, light levels of 500 lumens to 2500 lumens can be achieved at the same high levels of efficiency, which will permit the Litek lamp to be adapted to a wide range of lighting needs.

Limited tests indicated that the Litek lamp could be operated without harmful radio frequency interference in close proximity to a variety of household appliances, such as AM/FM radios, television sets, garage door openers, and tape recorders.

1.0 Introduction

The effective date of the subject subcontract was August 1, 1980. Work was initiated on this program on or about June 1, 1980 in anticipation of its award. The various tasks to be accomplished under this subcontract includes the following:

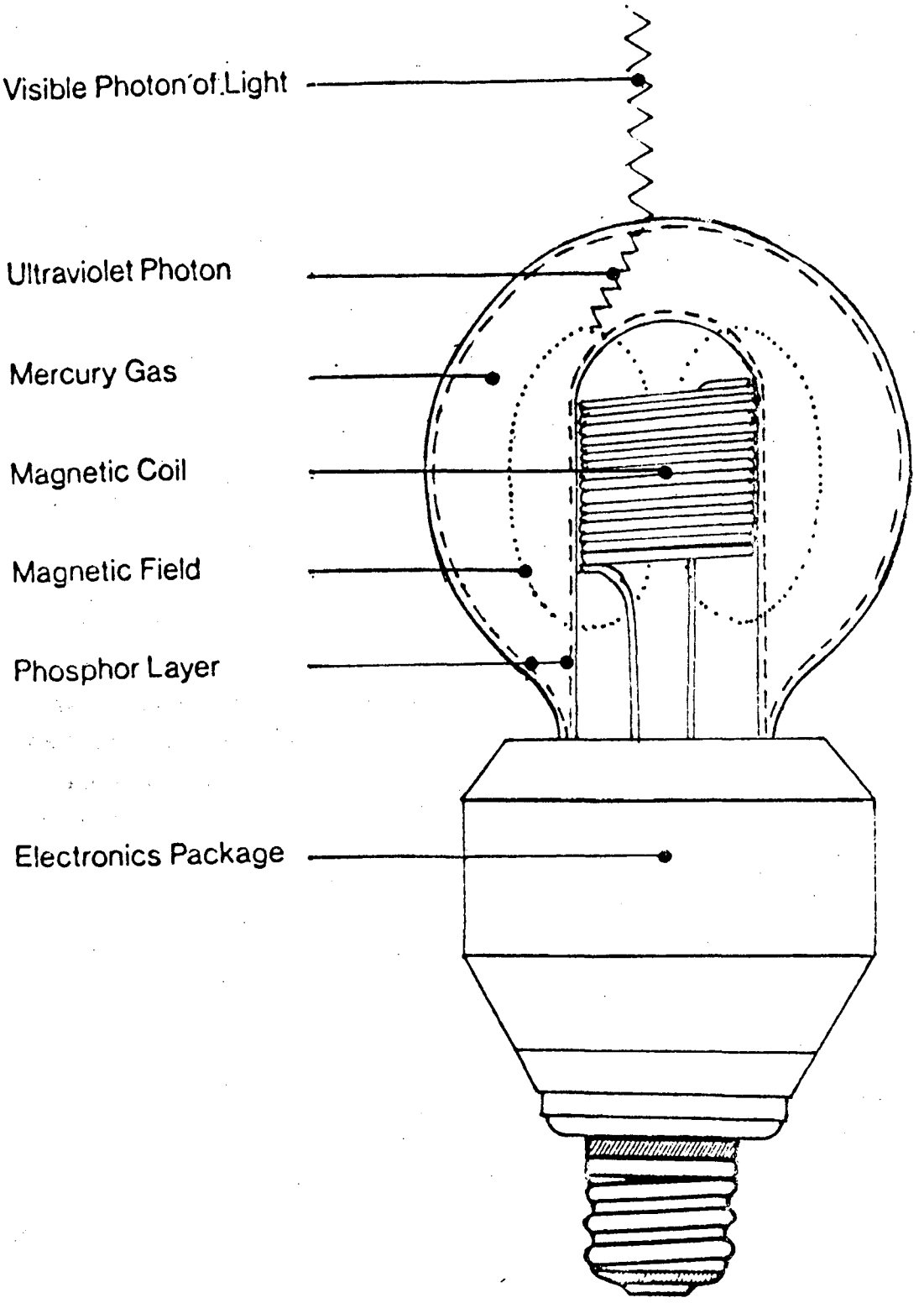
Task I - Program Plan
Task II - Production Design, Performance Targets
Task III - Testing Procedures
Task IV - Engineering, Testing
Task V - Market Research Plan
Task VI - Lamp Delivery of Ten (10) Prototype Lamps

The purpose of this program was to develop, test and deliver to LBL, ten (10) ea. prototype energy-efficient light bulbs as possible replacements for the conventional incandescent light bulb. This program was concluded on Sept. 25, 1981 with the delivery to LBL of ten (10) LITEK electrodeless fluorescent light bulbs all of which were delivering 1500 or more lumens at initial efficiencies of greater than 50 lumens per watt of A.C. power.

The Litek electrodeless lamp systems, which is shown in figure 1, consists of an electronic package which converts 120 volt A.C. household current to a high frequency oscillating current which, in turn, is used to excite a mercury-vapor gas mixture. The resulting ul- ultraviolet light energy is converted to visible light by a phosphor layer surrounding the bulb envelope.

Litek's development efforts, therefore, were focused on the two major components, the electronics driver and the lamp envelope.

Figure 1



LITEK

ELECTRODELESS FLUORESCENT

LIGHT BULB

1.1 Background

Previous developments efforts involving the Litek electrodeless fluorescent light bulb concept were supported, in part, by the U.S. Department of Energy. This work was undertaken by a predecessor company, Lighting Technology Corporation and resulted in the development of a compact electronic design which employed a Class C oscillator. However, the prototype lamps developed under this program had a relatively low light output, a low efficiency, and generated excessive heat.

2.0 Electronics Development

For the LBL program, a variety of prototype oscillator designs were constructed. Among these were a very efficient Class E design. However, it was discovered that this design was efficient only at very low power levels and could not be made to operate satisfactorily at the power levels required to operate the Litek lamp.

This effort culminated in the choice of a Class D oscillator design which employs two VMOS field effect transistors which act as high-speed switches. Although the Class D oscillator has a high theoretical efficiency, these efficiencies were not achieved initially because of the high on resistance and high internal capacitance of commercially available FET devices.

2.1 Transistor Development

LITEK, during the contract period, focused considerable effort on the development of a solid state device that would perform efficiently in our lamp circuit. We initiated two separate contract developments in this area, both of which produced satisfactory FET devices. As demonstrated to the UC/LBL representative on 9-25-81 the metal gate FET results in a lamp with an efficiency in excess of 55 lumens per watt, compared to nominal 52 lumens per watt efficiencies for the silicon gate devices.

3.0 Lamp Development

Initial lamp development efforts were directed toward attempting to identify and optimize the overall bulb shape and reentrant insert size in order to finalize and choose an appropriate coil size, shape and aspect ratio. It was imperative to establish a "design freeze" on the bulb shape since this, in turn, determined the coil size. This coil size, together with its length and aspect ratio, determined the inductance and capacitance ratio to which the electronics package needed to be designed to match efficiently. These studies resulted in the choice of a G-25 bulb shape, joined with a T-9 reentrant tube.

Unfortunately, at the time at which it was necessary for us to make this choice, the quality of the actual LITEK lamps were relatively poor, both in lumen generation and in uniformity. Consequently, it is possible that the G-25 & T-9 combination may not, in fact, be the optimum choice for the production lamp, and perhaps, even higher luminous efficacies might be achievable. However, since the electronics design necessarily had to proceed in parallel with the lamp development, such a major change could not be accomodated in the latter stages of the Phase I program.

During the entire Phase I program, our efforts to produce high quality lamps were plagued by a series of difficulties caused by contaminants within the lamp discharge. These contaminants would cause a rapid deterioration of the U.V. discharge and, consequently, of light output. As a result, a wide variety of materials, phosphor mixtures and lacquers were attempted with little success. In retrospect, the difficulties were all traceable to our lack of specific knowledge of lamp processing techniques.

Through greater care in the preparation of the lamp glass, the preparation and application of the lacquer and phosphors and in the lehring & sealing of the lamps, we are now able to produce very efficient lamps with a high degree of uniformity. Fortunately the techniques and process technology necessary to produce good quality lamps can be readily adapted to machine technology and high speed production processes.

The Phase I lamps employ a tri-stimulus phosphor system and a conventional nitrocellulose binder.

We have also experimentally explored the use of metallic getters to scavenge any residual impurities from the lamp discharge. When our lamps contained some impurities the use of a getter was helpful. However, as our processing improved, the use of a getter material appeared to produce no noticeable improvement in initial lumen output or luminous efficacy. However, there is published data which would tend to indicate that the use of getters might improve long range lumen maintenance. This remains to be investigated in the future.

4.0 Radio Frequency Interference

Considerable care and attention was given to the problem of potential interference with TV sets. The three ways in which RFI could occur were dealt with in the following manner:

4.1 Line Conduction

Potentially this is the most potent form of RFI. Fortunately, it is also very easily and effectively dealt with by using inexpensive line filtering within the lamp.

4.2 Circuit Radiation

This potential form of RFI is dealt with by enclosing the circuit in a RFI proof enclosure. For instance, the heat sink also serves as a portion of that enclosure.

4.3 Harmonic Radiation From The Glass Assembly

We have an RF coil within the insert of the glass assembly which will radiate all harmonics of RF energy supplied to it. Fortunately, such a coil is also a very poor antenna.

The output of the Class D amplifier switching point feeds a four element network which functions as both an impedance matching network as well as a filter. Proper selection of the components in this network allows us to reduce the harmonic signal strengths to a level which will not cause TV interference, as demonstrated to the UC/LBL representative. As also demonstrated, a thin coating of tin oxide on the exterior of the glass envelope will provide an additional level of RFI shielding if desired.

The lamps delivered under this contract do not cause any undue TV interference even without a tin oxide treatment.

This, we believe was adequately demonstrated on Sept. 25, 1981 wherein each of the ten (10) bulbs were operated in a relatively weak TV signal area (Hayward, Ca.) using a self-contained dipole antenna on a portable television set, where the television set was operated within 5 feet of each lamp.

The Litek lamp has also been informally tested with a variety of other household appliance such as AM Radios, FM Radios, garage door openers, tape recorders and similiar equipment. However, only the VHF television bands show any potential for interference because of the proximity of the signals to the harmonics of the 13.56 Mhz fundamental ISM frequency.

5.0 Specifications and Test Results

The operating characteristics and test results of the ten (10) Phase I lamps are as follows:

Power Input: 120 V. AC
Diameter: 3 1/8 inches
Length: 6 7/8 inches
Base: Std. Edison screw base
Weight: 9.5 oz.
Operating Position: Any
Frequency of Operation: 13.56 Mhz ± .05% (ISM Band)

Initial Lumens & Luminous Efficiency:

These measurements were conducted in Litek's integrating sphere which was calibrated to a National Bureau of Standards 100 watt incandescent lamp (Sphere calibration - 1 foot candle = 9.25 lumens).

LAMP NO.	FOOT CANDLES	LUMENS (L)	AC WATTS (W)	EFFICIENCY (L/W)
1	182	1683	29.7	56.7
2	168	1554	30.0	51.8
3	166	1535	29.3	52.4
4	170	1572	31.0	50.7
5	184	1702	32.1	53.0
6	176	1628	30.5	53.4
7	176	1628	31.0	52.5
8	173	1600	30.3	52.8
9	161	1489	29.0	51.3
10	1896	1748	33.0	53.0

Note: As explained to the UC/LBL representative lamp #1 has an increased efficiency due to the faster switching FET's developed for LITEK and is representative of our present performance efficiency.

6.0 Life & Lumen Maintenance

Because of the delays in producing good quality bulb envelopes, extensive life testing of the lamp system was not possible.

However, we were able to accumulate approximately 2000 operating hours on all ten (10) of the electronic driver units, using a variety of different bulbs.

The ten (10) bulbs supplied to LBL were of recent manufacture and had accumulated some 20-30 hours of operation without noticeable degradation. However, should any bulb fail within 10,000 hours of operation, we will replace it without charge to UC/LBL.

7.0 Cost Analysis

Independent of the subject subcontract, LITEK commissioned SRI International to undertake a technical design review and cost analysis of the Litek lamp in high volume production. Although the details of this study are considered proprietary to Litek International Inc., the conclusion of this study was that the total projected manufacturing cost in quantities in excess of 1,000,00 units per year was $2.66 per unit.

8.0 Market Research Plan

Task V of UC/LBL subcontract No. 4506310 called for delivery to LBL of a market research plan to solicit important information from proposed users and customers for energy efficient light bulbs. Litek's response to this task V effort is included herein as Appendix A. This report reiterates several questions posed in the study entitled "Shaping Substitute Incandescent Strategy" which was jointly prepared by the Carnegie-Mellon Energy Productivity Center and Mackensie & Co. Inc. in April 1979.

It is unfortunate that UC/LBL and the DOE were unable to proceed with this important market research effort since it would have elicited important user data and estimates of market size and penetration strategies which are essential for a company such as Litek to attract the private capital investment which is essential to commence mass production and mass distribution of the Litek lamp.

9.0 Conclusions and Prognosis

Litek believes that electrodeless fluorescent light bulbs represents the most commercially viable approach to a substitute light source for the standard incandescent light bulb. The Litek lamp is compact and can be produced in a wide range of light levels and sizes in order to meet an extensive range of lighting applications which can presently be served only by standard incandescent lamps. The use of newly-developed prime color phosphors instead of the more conventional calcium halophosphate coatings provide color rendering which is equal or superior to standard incandescent light bulbs.

Properly tooled for high-volume production, the energy-efficient Litek lamp can be manufactured and sold at prices which will be highly cost effective when compared to the comparable incandescent light blub.

MARKET RESEARCH PLAN

TASK V

The market research needed for the sucessful introduction of an energy-efficient subsitute for the incandescent light bulb was addresses in a study entitled "Shaping Substitute Incandescent Strategy" jointly prepared in April 1979 by the Carnegie-Mellon Energy Productivity Center and Makinsey & Co., Inc. This report raised five (5) important questions, as follows:

1) Will the consumer pay $10 to $15 for an item now selling for 75¢?
2) How much is the convenience of long-life worth to the consumer?
3) Will payback logic be understood and used?
4) Is fluorescent in the home simply unacceptable?
5) Will consumer's "supermarket budget" constraints require a new channel of distribution?

In this report, however, McKinsey observes that definitive answers to these questions may not be obtainable until actual products are offered for sale. However, in order for an EELB manufacturer to be in a position to offer a product for sale, even for demonstration purposes or for test marketing, a major investment in development cost, testing, capital equipment, set-up and other nonrecurring costs must be made. For any organization other than an established lighting manufacturer, such a major financial committment may not be obtainable in the absence of some reasonably reliable user information. Consequently, a company such as Litek could derive a great deal of potential benefit from a reliable analysis of the potential user market particularly if

it is sufficiently detailed to permit the incorporation of changes in features of design or utility into the final product which the market research might indicate are needed for the product to gain greater market acceptance.

Unfortunately, it is all too easy for those of us in government, industry or academia, who are committed to the commercialization of energy efficient light bulbs, to overestimate the importance of energy conservation in the sale of a product. For example, in 1977, the General Electric Company introduced a convenient fluorescent light called the BRITE-STIK*, which quickly gained widespread market acceptance. The product, selling for around $10 delivers approximately 25 lumens per watt-of energy, only slightly better than an incandescent light bulb. Subsequently, GTE-Sylvania introduced a very similiar product, called DAY-BRITE** Based on the manufacturers claims, this product delivers 40 lumens per watt of energy because of a more energy-efficient ballasting system. However, despite a 50% improvement in efficiency over the GE product and an almost 300% improvement in efficiency over an incandescent light bulb, the Sylvania product is virtually unavailable to consumers through retail stores in the San Francisco Bay Area. The important question is why? One obvious answer is that it is not necessarily the superior product that finds a place on the retail shelf.

The above example points up what we believe may be the more crucial question. "Will any present channel of distribution to the residential customer be effectively available to a superior EELB if it is not produced by one, or perhaps the, major lamp manufacturer?"

* Trademark of General Electric Co.
** Trademark of GTE-Sylvania

The residential market is extremely attractive to any EELB manufacturer because of the enormous volume and profit potential. Since this market encompasses over four-fifths of the existing incandescent lamp sockets, the importance of this market for potential energy conservation takes on ever greater significance.

PRIOR MARKET RESEARCH EFFORTS

In 1976, Stanford Research Institute performed a market survey of the Litek lamp which was entitled, "Business Development Strategy and Market for a New General Purpose Lamp" (SRI project MEC-5670 dated December 1976). Although this report was prepared with a particular lamp in mind, its analysis of markets and accessable replacement sockets, as well as its conclusions, are equally applicable to any other EELB. This report has been questioned on the basis that some of the conclusions drawn were not fully supported, however we believe the SRI report to be substantially accurate and still reasonably current. It is believed that future market research efforts could profitably undertake to address many of the questions which could not be adequately addressed by SRI because of time and budgetary constraints, and attempt to develop more fundamental consumer preference and attitude data regarding acceptance of EELBs, color preference, price sensitivity, etc.

Although we do not claim in house expertise in consumer market research techniques, we believe a most useful method of gathering the needed data would be the consumer panel. Practically all major companies who sell consumer products have comsumer panels available to them either through their own marketing organizations

or through their retained advertising and market consulting groups. Usually, a consumer panel will afford a manufacturer on opportunity to explore in depth, specific consumer/user attitudes toward a product, and with proper controls, a great deal of insight into the subjective factors which are important in the consumers decision-making process can be obtained.

Since the statistical numbers involved in the consumer panel approach are usually quite small, the possibility of statistical error in the selection of the sample, or bias in the interchange of information is rather large in relation to the market segment which the panel is selected to represent. Typically, the accuracy of the panel would be verified by independent means, such as a control group randomly selected. However, since the consumer panel represents a great opportunity to elicit information which is not otherwise obtainable, Litek believes this approach should be given serious consideration in the market study of EELBs which LBL proposed to commission.

Margaret Dana, a Philadelphia-based nationally syndicated consumer affairs columnist was instrumental in the establishment, in the mid-1970's, of a series of consumer panels which were called "Consumer Sounding Boards". This was an all-volunteer organization which was used to gather a great deal of important consumer information for various government sponsors and national trade associations, including the U.S. Consumer Product Safety Commission and the American National Standards Institute (ANSI). Consumer Sounding Board's were effectively utilized to evaluate and appraise numerous proposed product safety regulations and their associated cost factors as well as several voluntary industry standards. The services of an organization such as a Consumer Sounding Board would probably not be available routinely to a private organization, but could be made available if a

significant public purpose, such as energy conservation were involved.

Use of such a consumer organization could provide important user data not only as to the substitution of an EELB for a conventional incandescent light bulb, but also could provide important insight as to consumer attitudes/preferences between the competing technologies of all of the various EELBs under development.

Finally, Litek would like to see the LBL study address the question of the feasibility and/or advisability of the government or the private sector establishing a uniform standard for the measurement of light efficiency. Present lighting product packaging techniques offer a confusing and totally inconsistent manner of presenting lamp operating characteristics. For example, some will indicate initial lumens, some will indicate average lumens and still others will indicate neither. Many of the newly announced EELB products compare their projected life and light output to existing incandescent products, such as a 100 watt bulb. As can be seen, however, existing 100 watt bulbs may vary from an initial 1750 lumens and 750 hours life to 1000 lumens and a 3,000 to 5,000 hour life.

Litek suspects that, after nearly a century of experience with the incandescent light bulb. the average consumer has come to believe, incorrectly, that watts are a measure of the level of light. If the proposed market research program confirms these suspicions, it will tend to indicate the magnitude of the educational program needed to correct this misconception. Further, it may also point the need for an alternative criterion for the comparative evaluation of both incandescents and EELBs.

One unique approach which we believe is worthy of serious consideration is the "Service Cost" analytical technique. This approach was developed by Dr. Jordon J. Baruch, who is currently the Assistant Secretary for Science and Technology, U.S. Dept. of Commerce. However, this technique was developed and published while Dr. Baruch was Lecturer in Business Administration at the Harvard Graduate School of Business Administration, under a Grant from the National Science Foundation.

Dr. Baruch observed that the consumer does not purchase a "light bulb" but rather he purchases an "expectation of light". The service cost of illumination is determined by a collection of factors, including Lamp Efficiency, Life, Power Cost and the Labor Cost of Replacing Lamps. Accordingly, he suggested that unit of measure of one million lumen hours (one MLH) of light be established as the standard unit. The so-called Service Cost C per MLH of all lighting products could then be determined in accordance with the following formula:

$$C = \frac{10}{E} \left[\frac{P + TH}{WL} + R \right]$$

Where:

- C is in dollars per million lumen hour (MLH);
- E is the average efficacy of the lamp, in lumens per watt;
- P is the price of the lamp, in cents;
- R is the price of energy, in cents per kelowatt hour;
- W is the wattage of the lamp;
- L is the lamp life in thousands of hours;
- T is the time to change bulbs in hours; and
- H is the consumer's perceived hourly rate for his labor in cents.

By making appropriate substitutions in the Service Cost formula we find that the Service Cost of a standard 100 watt light bulb would be $6.55 per million lumen hours (MLH) if energy costs are 10¢ per kwhr, T is 0.1 hour, and H equals 500 cents. A comparable EELB, such as the Litek lamp, would show a projected rate of only $2.03 per MLH.

Litek believes that if such a direct "bottom line" standard comparison could be adopted, either as a voluntary industry standard or one mandated by the appropriate government agency, a major abstacle to consumer acceptance of energy efficient lighting products could be overcome with appropriate public education. The success achieved by the U.S. Dept. of Transportation in the establisheent of standardized miles-per gallon test for automobiles is a prime example of what could be accomplished with EELBs and other electrical appliacces. Moreover, public acceptance has been very good. Here again, the consumer panel would appear to be an excellent vehicle for measuring consumer comprehension and possible acceptance of such a new standard.

Irrespective of the market research or analytical technique which is employed to evaluate an EELB, certain fundamental information would, in Litek's opinion, be highly desirable and useful, and could, in fact, facilitate the availablity of resources necessary to address an identified market need. In preparing the list which follows we have not attempted to differentiate between the various market segments even though we recognize that the answers to be obtained and conclusions which may be drawn may be very different for different market segments.

1) Demographics of Purchaser/Decision Maker:
   a) Age
   b) Sex
   C) Education Level
   d) Income Level
   e) Marital Status
   f) Community Size
   g) Credit Cards
   H) Family Size

2) Susceptability of consumer to patriotic/energy conservation appeal.

3) Importance of the covenience of long-life. Is purchaser/decision-maker also involved in replacing burned-out bulbs?

4) Ability of purchaser to comprehend fundamental economics of:
   a) Life-cycle cost analysis
   b) "Service Cost" analysis ie, delivered cost per 1,000,000 lumen-hours (MLH)
   c) Present total annual cost of incandescent light bulbs.
   d) Local energy rates, both present and forecast.

5) Susceptability of purchaser to tax credits/purchase incentives.

6) Effect of color quality
   a) Is color quality an important factor? Why?
   b) Is color quality the determining factor? Why?
   c) Does consumer differentiate between sunlight and incandescent? Incandescent and fluorescent? Fluorescent and other?

7) Effect of product design/appearance.
   a) Does an overall configuration which is different from an incandescent light bulb appear to represent a better value?
      (ie. should an EELB look like a light bulb?)

8) Probable intended use for initial EELB purchase
   a) reading lamp
   b) kitchen
   c) bathroom
   d) entry
   e) passage way
   f) workshop/garage
   g) security light
   h) convenience or night light

9) Customers comprehension of power input (watts) and light output (lumens). (ie. has the potential customer come to assume that watts are a measure of illumination?)

10) Effect and depth of brand-name loyalty. Can brand name loyalty be overcome by:
   a) Superior product?
   b) added features? (such as dimmability; 2-piece bulb)

11) Motivational impact of product endorsements and test results. What organizations or agencies would have greatest credibility?
   a) Government
   b) Universities
   c) Utilities
   d) Trade associations
   e) Consumer reporting organization
   f) Famous personalities
   g) Major lighting companies
   h) Public or quasi-public testing laboratories

12) If a feature magazine article or new product announcement could be arranged, which publications are likely to have the greatest impact on the likely initial EELB purchaser.
   a) Readers Digest
   b) Good Housekeeping
   C) Popular Science Monthly

d) Popular Mechanics monthly
e) Popular Electronics
f) Better Homes & Gardens
g) Sunset
h) Mother Earth News
i) Time
j) Life
k) Moneysworth
l) Consumers Report
m) Other

13) Regional variations in attitude based on energy rates and other factors. For example, the Northeastern United States tends to have the highest energy rates, but a population which is skeptical of new technology. The Pacific Northwest has the lowest energy rates, but the population tends to be conservation-oriented. Where should you try to sell the EELBs initially?

14) Test Marketing Plan:
An actual test marketing effort is probably beyond the scope of the proposed LBL effort. However, the identification of a Representative Test Market Site, together with a suggested Marketing Campaign would be most helpful.

With reference to LBL letter (P.E. Marshall) dated June 3, 1980, which suggested several areas of coverage, our belief is that these areas tended to be conclusions to be drawn based on information obtained from the proposed market research program. In other words, the development of a market penetration philosophy or an advertising compaign would be best accomplished after one has identified a specific market need. However, based on previously obtained data we will attempt to address these matters, as follows:

a) Market Segment Strategy-
The existing incandescent lamp market lends itself to a some-

what natural division between the residential sector and all others. Even though the products, themselves, may be identical, the methods of distribution, dollar value and size of purchase, motivations of the purchaser, pricing, packaging and economic considerations may be vastly different.

Litek, since its inception, has generally adopted a marketing strategy which would be directed initially toward the commercial marketplace. The reasons for this strategy are generally contained in the SRI report, and include such factors as:

1) The purchaser is perceived as being more able to comprehend and appreciate the life-cycle cost effectiveness of an energy-efficient, long-life light bulb.

2) The purchaser is accustomed to making purchases based on expected future returns of invested capital.

3) The projected volume is much higher per sales call and direct sales to commercial/industrial accounts has been shown to be cost-effective in the past.

4) The commercial/industrial market can provide a baseline of experience, acceptance and public exposure from which other markets might be addressed.

However, we recognize that all EELB manufactures are likely to be similiarly motivated and will be competing for the same market share. Accordingly, Litek would be most interested to learn if the market analysis efforts demonstrated that some alternative marketing technique such as mail order, direct sales, distribution through utilities or oil company credit cards would appear to be a cost-effective method of addressing the important residential market.

Since Litek has no vested interest in any previously established distribution organization, we are in a somewhat more flexible position to take advantage of any alternative marketing approach which appears likely to succeed.

b) Market penetration philosophy. This, we believe would have to specifically tailored with respect to each market segment to be addressed in the commercial sector, a likely approach would be by direct sales to major users. To the residential sector, the approach might be on appeal to patriotism, or an appeal based on the technological uniqueness of the product.

c) Product distribution. Distribution technique would also depend upon the market addressed. However, it might also depend upon channels which are available to the manufacturer. Litek is inclined to believe that present methods of distribution of incandescent light bulbs are likely to prove too expensive for the distribution of an EELB because of the traditionally high mark-ups and low unit values. Also, we do not believe EELBs will sell well if displayed on the shelf alongside incandescents.

d) Product advertising. A successful advertising compaign would be tailored to the specific market identified and would emphasize those factors found to be persuasive with the largest numbers of potential customers. Early advertisements would likely include substantial educational material.

e) Product pricing. The pricing philosophy must, of necessity, cover the manufacturer total costs plus a reasonable profit. Beyond this, the actual price should be established only with reference to the projected long term gross margin. If the LBL market research program indicated extreme price resistance at any particulary point, that should be avoided. In any event, we believe that alternative price levels should be tried in a variety of test market conditions befor a nationwide marketing effort is undertaken.

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