F. H. BLAKE & ASSOCIATES
3103 - 149TH STREET, S. E.
MILL CREEK, WA. 98012

May 1, 1995

FINAL TECHNICAL PROGRESS REPORT--END OF PROJECT

(Assistance Instrument No. DE-F601-94CE15606. -DOE Grant, Inv. 606
"Fiber-Optic Anti-Cycling High Pressure Sodium Street Light Control")

This is the Final Technical Progress Report on the above DOE assistance grant. Because of the time that was required to process the request for the grant, we had progressed with the development of the control to a point where it was possible to make the 400 field test samples for the Utilities in the actual production computerized configuration. This is a considerable advancement over the original two-board interim design that was planned in the data submitted with the grant request.

The field test units are now being made with a single vertical PC board design and contains a "computer-on-a-chip" or PROM IC to take the place of the majority of the components previously contained on the upper logic board. This will reduce the final costs of the unit when it is in production and increase the control's flexibility.

The reason for this is that the single board design is considerably simplified and once the field test units have been demonstrated to the utilities, a ROM IC will be burned to replace the PROM, (Programmable Read Only Memory). The cost of the \$5.00 PROM then drops in price to less than 75 cents in the ROM form. It has replaced several dollars worth of IC components plus taking up much less room on the PC board. The total cost of the control will now be in the \$12 to \$16 range depending on the options wanted. This should be acceptable to the Utilities.

We have finished the soft tooling and have made the 400 plastic cases for the field test units. The new configuration of the cases entails a simplified design of the control shell which will have the lenses cast in place. The shell and base plastics are now finished and in final assembly awaiting the completion of the PC boards.

The circuit diagram, parts placement and software are completed and the controls are now being manufactured. Final assembly, test and calibration will be finished in the next few weeks. Future changes, if there are any improvements that the Utilities want, will merely be a matter of rewriting the software and will not involve any changes in the board circuit or the components on it.

The microprocessor design approach is quite an advantage over the previous idea of designing a full digital control chip, which would have been composed of 40 to 50 internal digital components. Such a chip once it has been designed and built, cannot be changed except to repeat the process over again). The price comparison of the digital approach design versus the PROM is approximately 8 to 1. To reprogram a ROM is roughly about a \$5,000 job against making a new digital chip of \$30,000 to \$40,000.

Prototypes of the actual control units have been tested to verify that it performs as designed. We are already contacting the Utilities to get the field test samples placed in strategic locations, in both large sized Utilities and certain smaller ones as well. Also we are arranging with certain industries to test the "Flat Pak" high bay fixture units that will be mounted inside of the fixtures to prevent operation of cycling lamps.

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**MR. TERRY LEVINSON, DOE PROJECT OFFICER
U. S. DEPARTMENT OF ENERGY, EE-521
1000 INDEPENDENCE AVENUE, S. W.
Washington, D. C. 20013**

**Subject: Assistance Instrument No. DE-FG01-94CE15606. -DOE Grant, Inv. 606 -
"Fiber-Optic, Anti-Cycling, High Pressure Sodium Street Light Control"
FINAL TECHNICAL PROGRESS REPORT, END OF PROJECT.**

Dear Mr. Levinson:

Referring to award Document DOE F 4600.1 and the subject FINAL TECHNICAL PROGRESS REPORT is submitted to your office and to the addresses shown below.

Work on the subject grant project is finishing several months ahead of shedule. I have followed very closely the Task Performance Schedule that was originally submitted to DOE for the grant except that I have accomplished the work several months earlier than originally anticipated.

The results of the new controls show that they have exceded what was originally thought possible. We have made the field test samples with computerized logic and it outperforms all the functions required of the new controls.

We thank you and all of the DOE personnel who made this grant possible and helped with its execution. These new controls will exceed the energy savings originally thought possible.

Very truly yours,

Frederick H. Blake, Owner

Enclosure: FINAL Technical Progress Report, Dated May 1, 1995.

✓ **CC: DOE, Office of Scientific & Technical Information, (OSTI), Oak Ridge, TN. 37830**

**CC: Lisa Tillman, HR-531.23, Contract Administrator, DOE,
Washington, D. C. 20585**

CC: DOE, Office of Controller, Germantown, Md. 20784

The project has gone on exceedingly well and the finished product actually does much more than was originally anticipated that the controls could do. We expect to be sending out finished field test units to the Utilities in the next few weeks.

I have enclosed with this letter a copy of the article on the device which was published in the April 24th issue of the Design News magazine. The "Dual-Dome" series of HPS controls was recently ranked among the finalists in their nationwide "Excellence in Design" contest held yearly by this trade journal.

Also included with this report are two data sheets describing: (1) The MODUS OPERANDI of the failure modes of the HPS lamp and how the new control protects the ballast/starters as well as signaling the type of problem involved to the utility crews. (2) A list of the requirements specified by the utility engineers of what features they most wanted built into the new controls.

This new ANTI-CYCLING control not only performs all of these functions and more but will eventually obsolete all of the present controls now being sold to control HPS street lights. With 50 million units of replacements being required in the next 7 to 10 years, this will be a very lucrative market for a manufacturing firm to enter into. I should have some success eventually in being able to license a control manufacturer to make and market this unit on a worldwide basis. We are obtaining the International Patents and have already obtained U. S. Patents on the device.

I thank all of the DOE personnel who have made this grant possible and the building of the new controls. The energy savings from these new controls will be a very considerable amount.

Very truly yours,

Frederick H. Blake, P. E.

ENCLOSURES:

DISCLAIMER

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Smart Photoelectric Control Senses Lighting Problems

Energy-saving device stops street lamp cycling

Gail M. Robinson, Contributing Editor

Mill Creek, WA—A common roadside feature, High Pressure Sodium (HPS) lamps exhibit a long life span—about 5 years. They eventually fail when the arc tube darkens and lamp voltages can no longer maintain a continuous arc within the bulb.

At that point, abnormal cycling takes place, and the lamp continually flashes or attempts to start. The condition can prove especially difficult to detect because of the infrequency of the cycling. If abnormal flashing continues for more than 2 to 3 months, the lamp's starter/ballast unit eventually becomes damaged. For a util-

ity company, this means expensive replacement of the defective lamp as well as the starter/ballast unit.

The Dual Dome Anti-Cycling HPS Street Lamp Control turns lights on at night and off in the morning, and protects against cycling. It photoelectrically senses lamp cycling using a single PROM that performs all of the logic functions in the control. "Previous attempts to disconnect cycling street lamps from their power sources required complicated circuits," says designer Frederick Blake of F.H. Blake & Associates. "Their reliability was questionable, and their cost excessive."

Mounted on the top of a conventional street light, the Dual Dome counts the lamp's attempts to start. After three on-and-off cycles during the night, it cuts current to the ballast, and a red strobe light located on top of the unit flashes on to alert maintenance crews. "The PROM combined with Triac switching simplifies the circuit and gives trouble-free life to the control," explains Blake. "The load is always switched at a current zero so that no large in-rush current is switched on or off."

Fiber-optic cable extends between the anti-cycling controller and the lamp. The cable's distal end is so positioned that a portion of the

light emitted by the lamp is transmitted along the cable to the controller. At the other end of the cable, a photocell generates an electrical signal that varies as light is transmitted, or not, through the cable. Input to the anticycling circuitry, this signal enables the controller to recognize abnormal lamp cycling.

Dual Dome's circuitry and power supply are mounted on a 2 3/8" x 2-inch-wide PC board housed in the 3-inch high, shatterproof Lexan® dome. Its fiber-optic cable extends from the housing; a low-heat-conduction fitting connects it to the fixture's reflector.

Under a Dept. of Energy grant, 500 field-test units are currently in production; they will soon be sent to major utility firms. Additional details...Frederick Blake, F.H. Blake & Associates, 3103 149th St. S.E., Mill Creek, WA 98012, (206) 337-5117.

Other Applications

- Parking areas
- Industrial lighting
- Building wash lighting

Did you find this article useful?
If so, let us know. Circle No. 524

Dual Dome control circuitry—housed in a 3- x 2-inch package—employs fiber-optic and PROM technology.

DUAL DOME HPS LAMP CONTROL

Protected against voltage surges, the Dual Dome control head incorporates a maintenance-free anticycling control circuit that detects defective street lights. It can be installed with a few common tools and a minimum of expertise.

BRIEF OF *MODUS OPERANDI* OF DD-102 SERIES "SMART" CONTROLS

NORMAL OPERATION:

When the power is first applied to the control after installation, after 4 seconds the LED blinks twice and 4 seconds after that, (total of 8 seconds), the power is applied to the Triac, turning "on" the ballast, (if the Day/Night sensor shows that it is nighttime).

The "*smart*" microprocessor IC chip in this computerized control not only checks out itself in the first 4 seconds of its operation but verifies that all of the circuitry connected to it is operating correctly also. When it blinks twice after being turned "on" the installer knows that it will run correctly and perform as programmed. No other checks are necessary. No bench testing in the utility's shop is required.

The Day/Night PE sensor turns "on" in 1 to 2 seconds after it is dark. It turns "off" 10 seconds after "seeing" light. It takes the 10 seconds of daylight to set the control to turn "off" the ballast. This protects it against operation by moving headlight glare. The control unit's Day/Night sensor is precalibrated at the factory. The settings can be specified by the utilities. Standard is 3- 1/2 f.c. "on" and 4 f.c. "off"

MODES OF MALFUNCTION OR FAILURE OF HPS LAMPS:

Failure Mode #1. When first starting to cycle, the cycling lamp causes the microprocessor to turn "off" the ballast for 2 minutes to allow the lamp to cool down. Then turns "on" the ballast and tries restarting the lamp. (To be considered a cycling lamp, it must burn and try to start for at least 1 minute or it is considered one of two types of defective lamps as shown in Failure Modes #2 or #3).

In the second try at restarting after deionizing and turning "off" for 2 minutes of lamp cooling, and if it still refuses to come up to full brilliancy but again dies, the ballast is again turned "off" for 2 minutes. It then tries a third time to restart the lamp and if again it fails to stay ignited, it turns "off" the ballast permanently and turns "on" the LED in a blinking mode.

The LED then stays "on" all the rest of the night and all of the next day and at sunset the Day/Night PE resets the control and everything starts over again. The utilities desire this repetitive operation each night because many times a line transient or a low line voltage will cause the lamp to accidentally cycle. The programming in the micro-processor is set to do this nightly repeat of the program automatically.

Failure Mode #2. If the lamp flickers when it tries to turn "on" but stays "on" for less time than 1 minute, the microprocessor treats it as one type of defective lamp, or a defective ballast or a defective starter. In this case the power is kept on the ballast for 5 minutes and then turns "off" for 2 minutes. It does this 3 times to attempt at getting the lamp restarted, (total of 19 minutes of elapsed time), then turns "off" the ballast permanently and lights the LED in a blinking mode.

Failure Mode #3. If the lamp doesn't turn "on" at all and is completely dead, the microprocessor considers it a defunct lamp but gives it 15 minutes of "on" time to verify it. It then turns "off" the ballast permanently and illuminates the LED in a steady state mode to show this type of failure. As with Failure #1 from cycling, both Failures #2 and #3 give the lamp three chance to start each every night thereafter until a new lamp is installed or other repairs are made to the fixture.

REQUIREMENTS OF A MODERN REPLACEMENT CONTROL FOR HPS STREET LIGHTS

By interviewing several hundred street light managers and engineers, the following list of the essential requirements for a new control device was compiled. It represents a consolidation of all requests into a absolute minimum list of what is required by the street lighting industry. A new control is urgently needed to accomplish all of these assigned tasks for the operation of an efficient street lighting system. A modern control device has long been needed to fill the void left by wholly inadequate units presently available to the industry. These are the requirements:

1. ANTI-CYCLING PROTECTION: Protection against the cycling is needed for the fixture, including its ballast and starter. Lamp cycling has caused problems since the HPS lamp was developed 30 years ago. Street lighting engineers also specified that some type of indication is necessary to indicate that the lamp and ballast have been locked out because of this cycling and other lamp and ballast/starter defects.

2. INCREASED CONTROL LIFE: The industry is completely unsatisfied with a life of 4 to 7 years, average, that they now obtain from the presently supplied controls. This must be increased to at least ten years, especially considering that the solid state ballasts for the HPS lamps now being developed will be available in a few years. The new electronic ballasts will increase lamp life probably by as much as 50%.

3. DIRECT REPLACEMENT FOR PRESENT CONTROLS: The new control must be a direct replacement for presently used controls. To limit stocking requirements, one type of control should fit any size of lamp up to 400 Watts, any of the usually employed supply voltages of 120 VAC, 240 VAC or 277 VAC and any of the 4 types of ballasts that are now commonly used in street light fixtures.

4. EASY INSTALLATION OF NEW CONTROL: New controls must be field installable and be easily and quickly put in place by the same personnel now used in street light maintenance. The work must be done without special tools and without special electronic knowledge.

5. REDUCE THE COST OF STREET LAMP MAINTENANCE DRASTICALLY: The cost of street light maintenance is now extremely high. Management believes these costs are unreasonable and must be reduced. It is realized that the control's first cost is not as important as some of the other factors and all factors count in the total. Yet the cost of the new control must not be out of reason. The control's cost must amortize in 1 year minimum from the savings in the operation of the street light system.

6. UNITS MUST NOT REQUIRE BENCH TESTING BEFORE INSTALLATION: The new control units must be delivered to the utility pretested, precalibrated and ready to operate. The installer will take them directly from the packing box and put them in place on the street light fixture. It must not be necessary to bench test them first.

7. MOST IMPORTANT OF ALL--THE NEW CONTROLS MUST BE RELIABLE: It is essential that the new controls be completely reliable and that the installer will know when he leaves the fixture location that the control will work as designed and that he won't have to return to the site later to fix it.

8. SOLVE THE HIGH CRIME RATE AREA MAINTENANCE PROBLEMS: This is becoming a very serious problem in the inner city areas. Assistance is needed in solving the maintenance costs and reliability of illumination in these districts. A general request for help was made for these areas hoping the control itself might be of help.