

Fixed Nonimaging CPC-type Troughs

Fixed nonimaging (NI) CPC type concentrating reflector troughs have solar radiation inlet aperture acceptance angles and fixed outlet apertures for collector-receivers (cookers, evacuated tubes, etc.). Compound parabolic concentrator (CPC) is a general term used by some to describe several types of NI concentrator shapes. NI fixed reflector troughs concentrate the beam and some of the diffuse solar radiation entering the trough according to the CPC acceptance angle, with relaxed construction tolerances (O’Gallagher, 2008).

NI trough shapes include: ordinary CPC (Winston), one-sided CPC, asymmetrical CPC, “sea shell” (Rabl), cusp-involute (Trombe-Meinel). And fixed troughs have adjustable/tracking end reflector options to let the solar radiation in one end, and usefully reflect at the other end avoiding spillage. Troughs are positioned mostly in EW lines, with NS inclined possibilities (Fig 2). CPC troughs with adjusted side reflector positions termed seasonal repositioning (SR) have an overall wider trough width. The fixed NI concentrating reflector shapes are integrated with architectonic form and structural configurations.

Building integrated fixed NI CPC type trough studies are presented in two main sections: exterior troughs and interior troughs; and exterior and interior troughs can be combined (Fig 1). Exterior NI fixed troughs are uncovered, without a glazing-roof, and are for

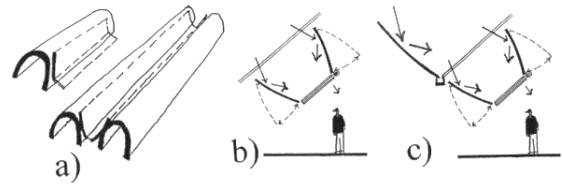


Fig. Building-size integrated nonimaging (NI) CPC-type concentrating reflector fixed trough configurations: a) exterior troughs; b) interior troughs; c) combined exterior and interior NI troughs

regions without snow accumulation, and inclined for lower latitude regions such as the Tropics. For example, a trough near the equator would be inclined more vertically so that the inlet aperture plane would be nearly horizontal.

Interior NI fixed troughs are covered with a glazing and are for regions with snow accumulation. For example, the Building Interior Evacuated Tubes and Reflectors (BIETR) has a monolithic tempered glass cover-roof.

Computer models have been developed with tested results indicating high efficiencies with relaxed trough construction tolerances. A Kreith and Kreider mathematical computer model accurately predicted CPC performance of CPC field testing at Argonne National Laboratory, Chicago, c1975 (1). Hour-to-hour annual computer simulation modeling of ± 35 deg. CPCs with ±10 deg. misalignment had less than 3% loss for Phoenix, Boston and Miami (3).

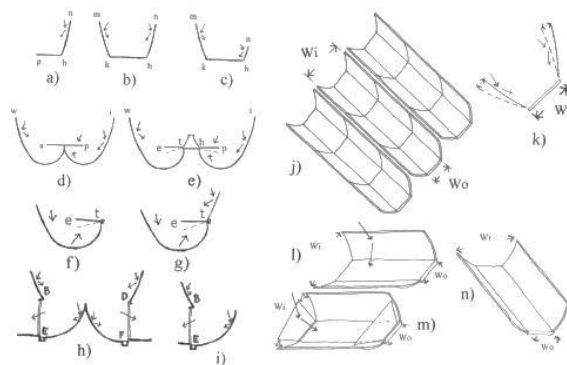


Fig Fixed Nonimaging Trough Shapes: a) one sided CPC; b) ordinary CPC; c) asymmetric CPC; d) involute; e) split involute; f) “sea shell”; g) “sea shell” plus; h) matched vertical outlets; i) vertical outlet; j) close packed troughs; k) adjustable CPC sides; l) E-W line troughs; m) adjustable/tracking end reflectors; n) N-S line inclined trough

(1) Giugler, Raymond M., Ari Rabl, K. Reed, V. Sevcik, and Roland Winston, *Compound Parabolic Concentrators for Solar Thermal Power, Semiannual progress report Jan.-June 1975*, Argonne National Lab., ANL-75-52, US ERDA Contract W-31-109-Eng-38, 1975

(2) Rabl, Ari, V. Sevcik, M Giugler, Roland Winston, *Use of compound parabolic concentrators for solar energy*, Argonne Nat Lab, Rep ANL-75-42, semiannual progress report, Jan 1975

(3) O’Gallagher, Joseph J., *Nonimaging Optics in Solar Energy*, (Synthesis Lectures on Energy and the Environment: Technology, Science, and Society), Morgan and Claypool, 2008

Fixed Exterior NI CPC Troughs

Building size reflector trough studies for solar cookers and solar kitchens include standalone concentrators, and small to midsize kitchens.

The introduction and use of portable solar cookers informs people about the suitability, convenience, and compatibility of solar cooking with existing building structures and site plan patterns. Kitchen and house designs based on the use of biomass (wood, dung, etc.) and fossil fuels for cooking often exclude the possibility of convenient solar cooking. Solar kitchens with building integrated solar cookers become a more significant design influence to building structure, form, orientation, and site planning.

From research studies for the tropical regions with building size stationary E-W line nonimaging (NI) CPC type reflector troughs (with moveable reflector end wall options) an interrelated set of design variables have been identified which include: site specific optimum CPC tilt and truncation; cooker-oven-storage inlet dimensions; convenient oven-location dimensions for kitchen workers; structural substrate of CPC, kitchen building structure, and kitchen building plan and spatial requirements. An intermediate aim is to arrive at viable designs for modest size and modest cost demonstration projects. The NI trough solar kitchen designs can significantly modify the form of the built environment, and CPC reflector substrate structures can be scaled up to large building size structures for process heat applications.

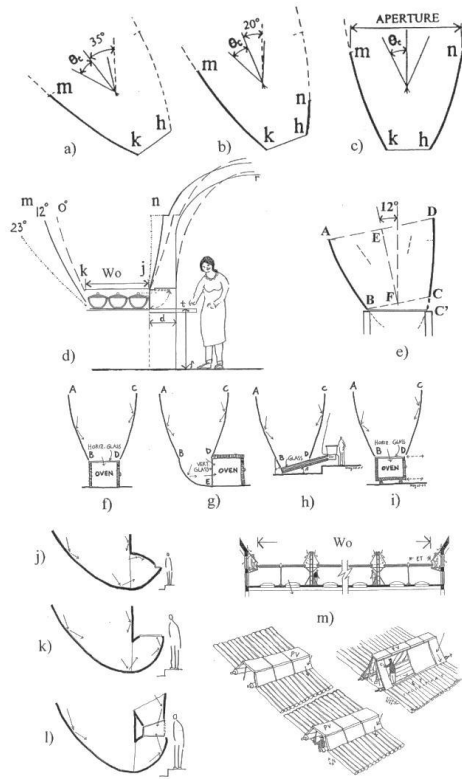


Fig Fixed exterior NI CPC trough diagrams

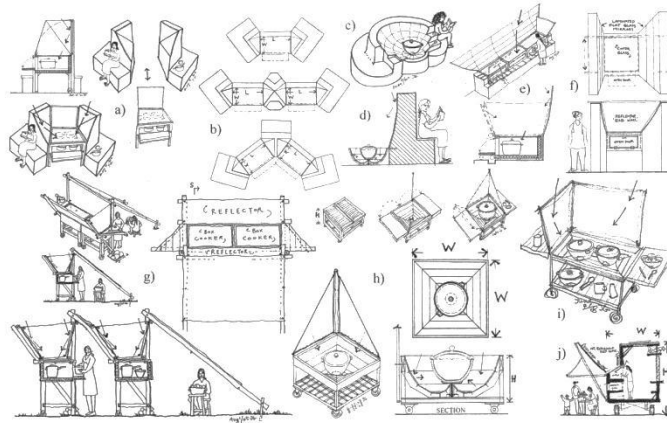


Fig. Stand alone nonimaging solar cookers

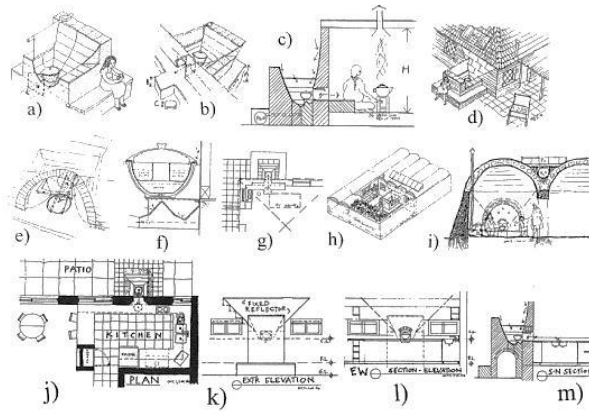


Fig. Thru wall fixed nonimaging solar cooker kitchen studies

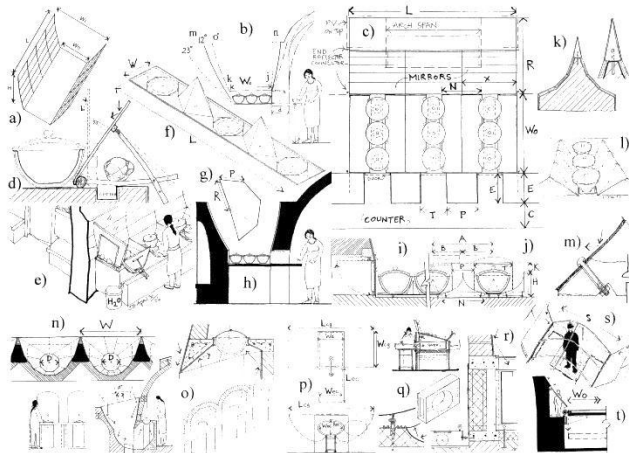


Fig. Exterior nonimaging troughs building integrated

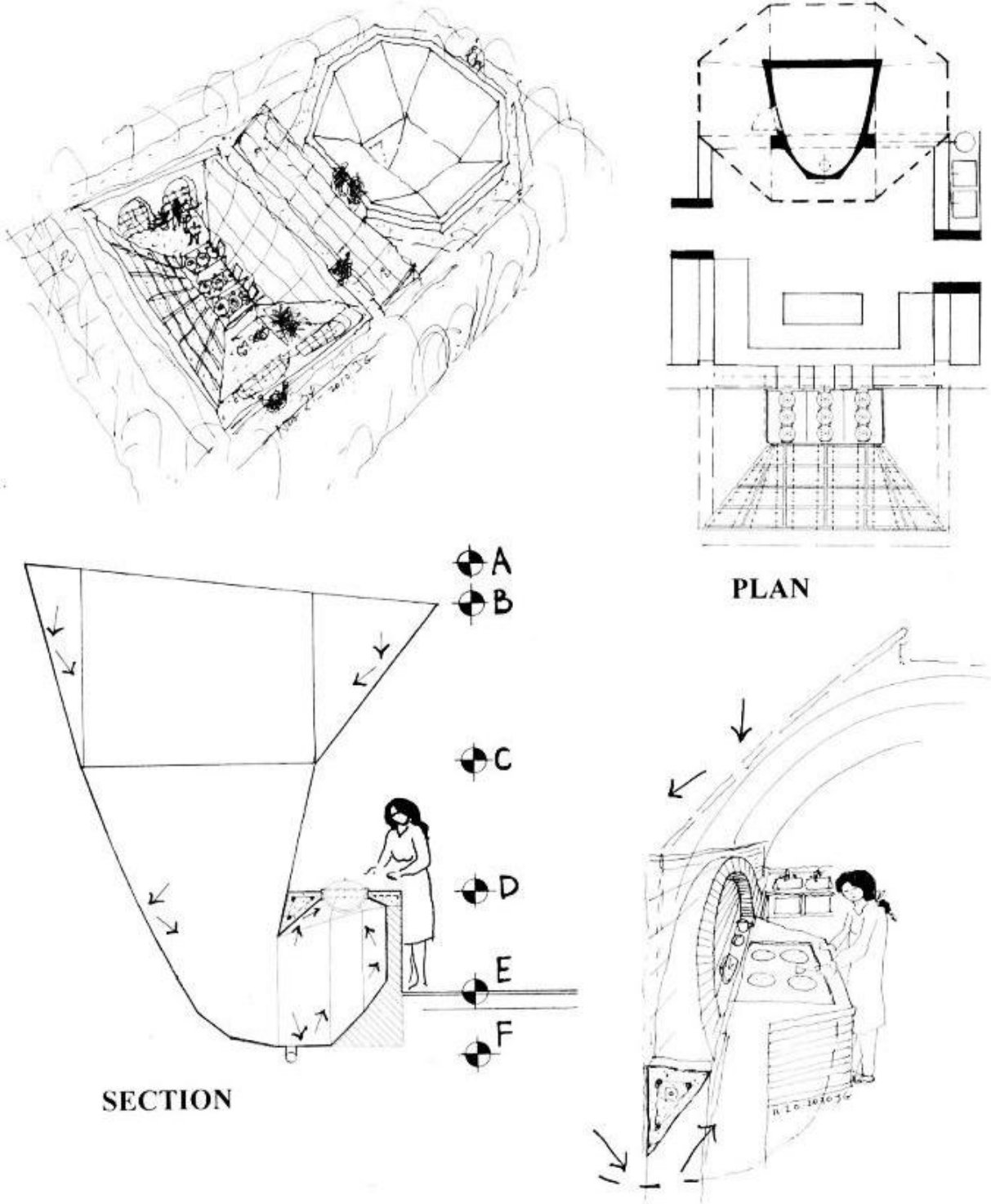


Fig Fixed nonimaging concentrator solar cooker kitchen

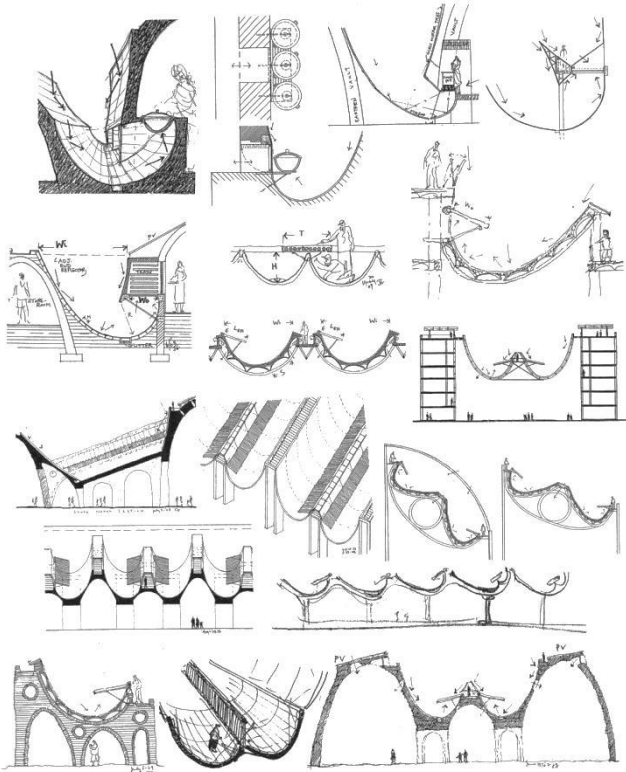


Fig. Building integrated fixed nonimaging troughs

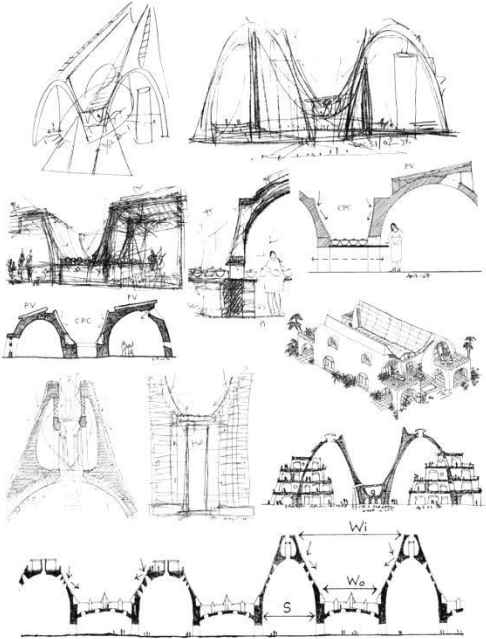


Fig. Building integrated nonimaging troughs