DEVELOPMENT OF "STUD HUGGER" SYSTEMS FOR INSULATING WALLS WITH CELLULOSE FIBRE INSULATION

By R. E. Platts, P. Eng.

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Ottawa, 23 October 1995

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ABSTRACT

The newsprint cellulose insulation industry has long wanted to supplant mineral fibre batts in insulating walls in house construction, and tests show that pumped ("blown") cellulose can do a superior insulation job - given a supporting enclosure for the open interior face of the framed wall cavity. Following a brief review of two failed attempts to provide such support (the first, a site-manufactured polyethylene-skinned cellulose batt, the next a moveable, snugly fitting plastic form) this report recounts the successful R&D which, with support from CMHC's HTIP program, offers the industry a workable and competitive system. The "studhugger" approach first used a set of moveable rigid stanchions to hold the polyethylene air-vapour retarder against and slightly around each stud, drawing it drumskin taut to act as a firm formwork to contain the cellulose as it is blown into the cavity. Full trials in the field revealed some important limitations but led to an apparently complete solution: the studhugger/polyethylene concept was transformed to become a fixed "cupped batten" that is stapled onto the framing to secure and tighten the poly. The trials of paper composite battens were successful; the battens could also be economically extruded from recycled scrap polyethylene or like plastics.

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EXECUTIVE SUMMARY

Testing and field performance have long shown that recycled newsprint cellulose fibre can readily provide excellent insulation value, permanently, when pumped or "blown" into the enclosed cavities of existing walls. Unfortunately, new construction does not offer such enclosed spaces to contain a pumped fill: the electricals, insulation and vapour retarder work must proceed before the interior finish is installed.

Prefabricated "batt" insulations were developed to allow new construction to proceed quickly and inexpensively. But batts don't do the job as well - and they are not easily made from newsprint fibre or other fully recycled materials. Their placement tends to leave indentations at corners, resulting in vertical gaps and convective "short circuiting" which reduces their thermal resistance. NRC Canada has shown a 15% to 30% reduction through such normal flaws in final fit. Such confirmations are encouraging the cellulose fibre industry to try harder to take the new construction wall insulation market away from the mineral fibre batt producers.

Our Canadian venture began with a "flanking" manoeuvre in concert with a U.S. partner. Earl Murray, the dean of the cellulose industry and founder of Regal Industries in Indiana - the largest such plant in the world - attempted to meet the glass fibre competition head-on: make better batts, using newsprint cellulose "sausage skinned" in polyethylene film. There were intrinsic problems in concept, fabrication, and handling, however; worse, NRC Canada testing suggested that the skinned batts could suffer similar performance shortfalls as mar the conventional mineral fibre batts. **(Photos 1 - 4)**

Our next step in Canada was to develop a flexible panel "moveable formwork" system (**Photos 5 - 8**), trying to improve upon the cellulose interests' rigid panel types that are described in the patent literature through the decades. Our oak-and-polycarbonate prototype worked well - to NRC approval as far as we went - snugly conforming to the studs even where irregularly spaced or crooked, and featuring sliding plates and cutouts to fit around electrical boxes. Since we first applied the poly film vb over the whole wall (having foamed in all narrow spaces such as around windows), there was no need to have the cutouts fit closely around electrical boxes; the poly itself provided the formwork across gaps and even over small cavities such as under windows. All of this failed as well, however: there are too many odd heights, awkward corners and poorly set electrical boxes in most house walls.

But the work did show one thing: 6-mil polyethylene can act as a perfect form in spanning small gaps. Ian Platts became stubbornly intrigued with this, thinking that it should be feasible to make the polyethylene do the whole job - after all, it has to cover the whole wall: cavities big and small, rectangular or oblique. He ventured to make a rough mock-up to try his unique clamped-poly idea: a moveable set of "stud hugger" stanchions to hold the film onto and slightly around the stud, pulling it as taut as a drumskin to retain the pumped fibre at adequate pressure and density without too much bulging of the film or intrusion of the fibre between it and the stud - both of which would interfere with drywall application. The mock-up worked: the taut polyethylene became the complete formwork.

Encouraged, Ian built a full set of "working mock-ups" to allow trials on full wall sections. These stud-hugger stanchions **(Photos 9 - 12)** featured a temporary top channel and a foot lever to jam them in place, and a bowed design to apply uniform pressure against the full height of the stud **(Figures 1 and 2, from Patent Application 2,097,849, Ian Platts, 1993/08/05).**

But full house "proof of concept" trials served to dash hopes and sustain them: the crude system failed, the concept worked. With a long R&D road ahead, we sought and received help from CMHC's HTIP program.

R&D on the moveable stanchion "studhugger": Setting up a home-based shop and "lab" at 12 Bedford Crescent in Ottawa, the engineers used the HTIP opportunity to good effect. Loads and equivalent pressures were measured on a simulated stanchion section, a test frame, with its "hugger" pad compressed to the known range of effective deformations - **Photos 13 - 15**. Allowable deflections and stanchion stiffness requirements were then determined in conjunction with the "hugger" pad design and compression tolerances, to maintain the required pressure and poly profile around the stud **(Figure 3)**. The deep foam hugger pad compresses over protruding electrical boxes and window sills with ease.

Rugged, lightweight working prototypes stanchions were designed and fabricated from "Paralam" (parallel strand lumber), **Photos 16 - 19** and **Figures 4 & 5**, giving just the required precision and stiffness. Production models would probably use aluminum. Trials on a test frame **(Photos 20 - 26)** showed the need for a spring toe support to position and hold the stanchion until its "foot jack" forced and locked it in place. Power screw points were fitted for anchoring where no ceiling strapping is used - most of U.S. housing, as a critically important example.

Full-scale pilot runs: In Indiana, Regal Industries enlisted a builder to try the working prototypes in houses underway near the Crothersville plant and research facility, Lakeside Lab. **Photos 27 - 31** show the productive scene, where the insulation trials were accompanied by immediate feedback and refitting of the stanchions in the machine shop. For example, quickly scorning the power screw alternative where no ceiling strapping is in place for top anchorage, Regal devised, made and fitted inverted claws to grip under the top plate, **Photo 30.**

Everything worked smoothly over most of the wall area - but not all. The major problem: the house, a bungalow on a PWF basement, presented three different "regular" wall heights as well as the stairwell longs and usual shorts. Detailed plans for extensible stanchions were devised. Further, a cathedral ceiling begged for a "centre grab" device to secure the stanchions, and that improvement would indeed apply to the whole system **(Figures 6 - 8)**. That, and other awkward areas, got Earl Murray thinking about a fixed studhugger strip that would be an adjunct to the moveable stanchion. Finally, the most critical problem: When the stanchion sets are moved along, the polyethylene slackens; the cellulose column generally remains stable while awaiting full support from the drywall, but the nailing of siding before that can dislodge some of the fibre to intrude between film and stud to an amount that interferes with easy drywalling - and can sometimes make the unsupported column of fibre settle away from the top plate. That action had not been simulated well enough in the earlier trials.

The cupped batten studhugger: The idea of fixed batten studhuggers came forward first as an adjunct to the moveable stanchion approach, to fill in the problem areas noted above. Back in the Ottawa lab, the "cupped batten" studhugger evolved to supercede the stanchion altogether; the project turned the last corner and drove home.

A fixed batten studhugger has to do the same job as the stanchion in pressing the film inward and drawing it taut; most of the foregoing work on pressures and profiles still applied. Its curved section must be stiff while remaining thin and easily stapled and drywall-screwed. And it must be cheap - perhaps not more than $0.03-0.04 per foot to the tradesman - because it remains in place as an additional cost burden.

Prototype cupped battens were cut from laminated paper, **Photo 32** (3 in. OD mailing tube stock, for these purposes); the final product might be that or, perhaps better, extruded polyethylene from low-grade recycled stock. These worked well on the test rig in Ottawa, the third-circle size behaving best in stapling as well as profiling/tightening the poly film just right. Regal set up a test wall and proceeded to try the new studhugger idea thoroughly, **Photos 33 - 43**. The trials used the heavy 6-mil polyethylene as presently required in Canada. Regal's engineer Ralph Sweeney designed the test wall for repeated testing with a single application of film and cupped battens, with trap doors in the sheathing to allow the cellulose to be cleaned out between trials, **Photos 39 & 40**. Such removal, in addition to hammering the wall to try to settle the fibre, proved its ability to stay in place - **Photos 41 & 42**. Trials such as in **Photo 43** confirmed that neither the battened stud condition nor the film bulge interferes with the application of drywall.

The team has kept the patent applications up to date in both Canada and the USA, adding the cupped batten as well as the extensible stanchion and centre-grab improvements to the original concept. Regal has now costed the new systems, and they appear promising to compete well against mineral fibre batts while offering better thermal performance and, of course, the proper use of recycled "wastes".

The Canadian part of the team now includes an industry scientist partner, and is poised to sign up industry to launch the cupped batten system with extruded plastic. Finally, it has to be said that the work would not have proceeded without CMHC's HTIP support; and once it did proceed, Regal Industries' energy, astuteness and integrity have been pivotal in moving this sometimes tenuous and amateurish quest into a promising North American venture.

RÉSUMÉ

Les résultats des essais et le rendement en situation réelle ont bel et bien démontré la valeur de la fibre cellulosique, provenant du papier journal recyclé, comme isolant permanent lorsqu'elle est injectée (par pompage ou soufflage) dans les cavités fermées de murs existants. Malheureusement, la construction neuve ne prévoit pas de tels espaces clos que l'on pourrait remplir de fibre cellulosique injectée : les installations électriques, l'isolant et les pare-vapeur doivent être posés avant le revêtement intérieur.

Des nattes isolantes préfabriquées ont été conçues pour que la construction de logements neufs soit rapide et peu coûteuse. Cependant, elles ne sont pas très efficaces; de plus, il est difficile de les fabriquer avec la fibre à papier journal ou d'autres matériaux entièrement recyclés. Les coins des nattes une fois installées ont tendance à faire des creux, créant ainsi des brèches verticales et des « courts-circuits » de convection qui en réduisent la valeur de résistance thermique. Les nattes isolantes résistent donc moins bien à la chaleur. Le Conseil national de recherches du Canada (CNRC) a montré que la résistance à la chaleur des nattes était réduite de 15 à 30 p. 100 en raison des imperfections habituelles persistant après la pose. Ces affirmations motivent le secteur de la fibre cellulosique à s'efforcer davantage de dérober le marché de l'isolation des parois aux fabricants de nattes de fibre minérale.

Notre aventure canadienne a débuté par une « manoeuvre de flanc » menée avec un partenaire américain. Earl Murray, un promoteur chevronné du secteur de la fibre cellulosique et fondateur de l'usine Regal Industries dans l'État de l'Indiana - la plus importante du monde - a tenté de s'attaquer de front à la concurrence du secteur de la fibre de verre en fabriquant de meilleures nattes avec de la fibre cellulosique enveloppée d'une mince feuille de polyéthylène comme un « saucisson ». Cependant, il a dû faire face à des problèmes de conception, de fabrication et de manutention; par surcroît, les essais du CNRC ont révélé que les nattes en « saucisson » pouvaient présenter les mêmes problèmes que les nattes de fibre minérale classiques **(photos 1 à 4).**

La démarche suivante de notre aventure canadienne consistait à concevoir un système mobile de panneaux de coffrage souples (**photos 5 à 8**) pour faire mieux que les panneaux de type rigide décrits dans les demandes de brevet aux cours des dernières décennies. Notre prototype de chêne et de polycarbonate a très bien fonctionné - à tout le moins, le CNRC l'avait approuvé - il s'ajustait bien aux montants même s'ils étaient croches ou mal espacés et comportait des lames coulissantes ainsi que des entailles s'adaptant au contour des coffrets électriques. Puisque nous avions tout d'abord appliqué un mince revêtement de polybutyral de vinyle sur toute la surface du mur (ayant formé une mousse qui a rempli les petites cavités comme celles autour des fenêtres), il n'était pas nécessaire d'ajuster avec précision les entailles autour des coffrets électriques; le polybutyral de vinyle même constituait le coffrage pour couvrir les brèches et les petites cavités comme celles que l'on trouve sous les fenêtres. Malgré tous nos efforts, notre projet a été infructueux; en effet, les maisons ont rarement des murs de la même hauteur et regorgent de coins peu commodes et de coffrets électriques mal installés.

Notre projet a cependant révélé un fait saillant : le polyéthylène 6-mil peut parfaitement servir de coffrage pour les petites brèches. Fort intrigué par ce fait, Ian Platts pensait qu'il devait y avoir moyen d'utiliser du polyéthylène sur toute la surface - après tout, on doit l'employer pour couvrir le

mur entier ainsi que les cavités, petites, grosses, rectangulaires ou obliques. C'est ainsi qu'il a entrepris la conception d'une maquette pour tester son idée originale de polyéthylène serré contre les montants. Pour ce faire, il a conçu un ensemble de supports serre-montants (stud huggers) pour fixer aux montants sa mince enveloppe de polyéthylène de manière à ce qu'elle soit tendue comme une peau de tambour et maintienne la fibre injectée à une densité et à une pression adéquates tout en évitant le bombage de l'enveloppe de polyéthylène et l'infiltration de la fibre entre cette enveloppe et le montant, ce qui nuirait à la pose du revêtement de gypse. La maquette fut un succès : le polyéthylène tendu constitue à présent le seul coffrage utilisé.

Encouragé par sa découverte, Ian a construit un ensemble complet de « supports types de travail » pour réaliser des essais sur des sections complètes de mur. Ces supports serre-montants (**photos 9 à 12**) se caractérisaient par une planche temporaire sur le dessus et un levier actionné avec le pied permettant de les tenir en place ainsi que par leur forme en arc permettant d'exercer une pression uniforme sur toute la hauteur du montant (**figures 1 et 2 dans la demande de brevet 2,097,849 rédigée par Ian Platts le 5 août 1993**).

Les essais permettant de mettre à l'épreuve ce concept de fond en comble ont à la fois éteint et ravivé notre flamme : le système à l'état brut avait échoué, mais le concept fonctionnait. Une longue période de recherche et développement nous attendait; c'est pourquoi nous avons fait appel au Programme d'encouragement à la technologie du bâtiment résidentiel (PETBR) offert par la SCHL, qui nous a accordé une subvention.

Recherche et développement concernant les supports serre-montants mobiles : Les ingénieurs ont utilisé les fonds du PETBR à bon escient en aménageant un atelier et un laboratoire à domicile au 12, rue Bedford, à Ottawa. Ils ont mesuré les charges et les pressions équivalentes sur une section de supports simulée, une ossature d'essai, jusqu'à ce que les coussins d'appui des serre-montants soient déformés selon certaines mesures (**photos 13 à 15**). Ils ont pu alors déterminer les flexions admissibles et la rigidité souhaitable des supports ainsi que la conception des coussins d'appui des serre-montants et les tolérances à la compression pour maintenir la pression nécessaire et le polyéthylène autour du montant (**figure 3**). L'épais coussin d'appui de mousse des serre-montants se comprime aisément par dessus les coffrets électriques saillants et les appuis de fenêtre.

Des supports serre-montants types de travail légers et robustes ont été conçus et fabriqués avec un panneau de copeaux longs (Parallam), **photos 16 à 19 et figures 4 et 5**, nous donnant ainsi la précision et la rigidité voulues. Les modèles de série devraient probablement être fabriqués avec de l'aluminium. Des essais sur une ossature d'essai (**photos 20 à 26**) ont révélé qu'il fallait installer un support de pied à ressort pour positionner le serre-montant et le maintenir dans cette position jusqu'à ce qu'il soit poussé et enclenché en place par le levier actionné avec le pied. À titre d'exemple très important, l'ancrage a été effectué à l'aide de vis (insérées par des trous prévus à cet effet) dans les maisons non dotées de tringles de plafond - comme c'est le cas pour la plupart des maisons aux État-Unis.

Essais pilotes à l'échelle réelle : Dans l'État de l'Indiana, l'usine Regal Industries a embauché un constructeur de bâtiments pour essayer les serre-montants types de travail dans des maisons en construction près de l'usine Crothersville et du centre de recherche Lakeside Laboratory. Les

photos 27 à 31 nous amènent sur les lieux où les essais d'isolation, suivis d'une rétroaction et de la modification des serre-montants dans un atelier de construction mécanique, ont été effectués. Par exemple, après avoir rapidement rejeté l'emploi de vis pour l'ancrage dans les maisons non dotées de tringles de plafond, Regal Industries a inventé, fabriqué et ajusté des pinces inversées pouvant s'agripper sous la sablière supérieure (**photo 30**).

Dans l'ensemble, tout s'est bien déroulé, sauf pour une partie des murs. Nous étions confronté à un gros problème : les murs du bungalow construit sur fondation en bois traité étaient de trois hauteurs différentes, sans compter les diverses longueurs et hauteurs des puits d'escalier. Des plans détaillés pour la fabrication de supports extensibles ont été élaborés. Autre problème, les supports ne pouvaient pas être fixés à un plafond cathédrale pour lequel il a fallu concevoir une « griffe centrale de maintien ». L'invention de cette dernière a grandement amélioré le système entier (**figures 6 à 8**). Outre les problèmes mentionnés, certains murs présentaient des coins peu commodes qui ont incité Earl Murray à inventer une bande serre-montants fixe servant d'accessoire aux supports mobiles. Enfin, notre problème le plus sérieux a été le suivant : lorsqu'on déplace l'ensemble des supports, le polyéthylène se relâche; la colonne de fibre cellulosique demeure généralement stable avant d'être définitivement soutenue par les panneaux de gypse, mais, si l'on cloue un bardage auparavant, la fibre peut se défaire et s'infiltrer entre la feuille de polyéthylène et le montant au point d'entraver la construction des murs secs - et la colonne de fibre peut même parfois se séparer de la sablière supérieure. Cette situation n'a pas été simulée à fond au cours des essais antérieurs.

Invention du profilé serre-montants (cupped batten studhugger) : L'idée d'un serre-montants fixe est d'abord venue comme accessoire du support mobile pour régler les problèmes susmentionnés. Pendant ce temps, notre laboratoire d'Ottawa mettait au point un profilé serre-montants qui est venu remplacer les supports serre-montants; notre projet avait finalement atteint son but.

Le profilé serre-montants fixe doit remplir les mêmes fonctions que le support, c'est-à-dire qu'il doit pousser la feuille polyéthylène vers l'intérieur tout en la maintenant tendue et doit réussir les mêmes tests de pressions et de profils que nous avons mentionnés. Son arc doit être rigide, mais il doit être mince, facile à agrafer et assez souple pour pouvoir être écrasé par les panneaux de gypse. De plus, son prix doit être abordable, car il représente des frais supplémentaires aux yeux des corps de métier - en d'autres mots, il ne doit pas dépasser 0,03 $ à 0,04 $ du pied.

Dans du papier contrecollé, on a taillé le prototype des profilés serre-montants, **photo 32** (à cette fin, nous avons employé des tubes d'envoi de 3 po de diamètre extérieur); le produit fini peut être fabriqué de la sorte ou, mieux encore, on peut employer du polyéthylène extrudé recyclé de qualité inférieure. Ces matériaux ont produit de bons résultats dans le banc d'essai à Ottawa, mais les profilés dont l'arc représente 1/3 de cercle peuvent non seulement être agrafés plus facilement mais encore tendre et retenir parfaitement la feuille de polyéthylène. L'entreprise Regal Industries a bâti un mur d'essai pour évaluer en détail ce nouveau concept de serre-montants (**photos 33 à 43**). Les essais ont employé du polyéthylène 6-mil lourd comme l'exigent les lois canadiennes. Ralph Sweeny, ingénieur de Regal Industries, a conçu le mur d'essai pour qu'il puisse subir plusieurs tests avec une seule enveloppe polyéthylène et des profilés serre-montants, et des trappes avaient été installées dans le revêtement primaire pour permettre le nettoyage de la fibre cellulosique entre les essais (**photos 39 et 40**). Ce mur d'essai éprouvé est resté en place malgré l'enlèvement de la fibre et du martelage du mur pour faire descendre la fibre (**photos 41 et 42**). Des essais comme celui de la **photo 43** ont confirmé que ni le profilé serre-montants ni le bombage de l'enveloppe n'entravent la pose des panneaux de gypse.

L'équipe a mis à jour les brevets d'invention canadiens et américains en ajoutant au concept original le profilé serre-montants, le support extensible et les griffes centrales de maintien. L'entreprise Regal Industries a estimé les coûts des nouveaux systèmes, qui promettent de livrer une concurrence féroce aux fabricants de nattes de fibre minérale, donnent un meilleur rendement thermique et, bien entendu, utilisent des produits recyclés.

L'équipe canadienne compte à présent un scientifique du secteur et est sur le point de signer un contrat avec l'usine pour mettre en marché le système de profilés serre-montants en plastique extrudé. Enfin, nous tenons à souligner que, sans le concours du Programme d'encouragement à la technologie du bâtiment résidentiel (PETBR) offert par la SCHL, nous n'aurions pas pu mener notre projet. Le travail acharné, l'ingéniosité et l'intégrité du personnel de Regal Industries ont permis de transformer nos efforts de recherche, parfois précaires et amateurs, en une entreprise nord-américaine fort prometteuse.

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DEVELOPMENT OF "STUD HUGGER" SYSTEMS FOR INSULATING WALLS WITH CELLULOSE FIBRE INSULATION

Report for the Housing Technology Incentives Program, Canada Mortgage and Housing Corporation
Ottawa, 23 October 1995

BACKGROUND

Insulating walls has normally involved the use of prefabricated "batts" of mineral fiber material, a process marked by the advantages of speed and conformance with other operations but marred by substantial disadvantages:

a) Batt insulations, depending upon a high degree of "springback" to allow their shipping in an economically compressed state, cannot be readily manufactured from recycled cellulose fibres, in particular shredded newsprint.

b) Batts must be "cut and fit" to attempt to fill the wall cavity between framing members of irregular spacing, and in any case their placement tends to leave indentations at corners, resulting in vertical gaps and convective "short circuiting" which reduces their thermal resistance. Recent testing at NRC Canada has shown a 15% to 30% reduction through such normal flaws in final fit; the discouraging effects of common misfits and, worse, the gap resulting from incomplete springback have been known to building scientists since Norwegian and U.S. testing in the 1960s.

For these reasons, as well as to achieve savings in costs (and, in recent years, to utilize sustainable "waste" resources and much less energy in production), several inventors have pursued the goal of using loosefill cellulose insulation for wall construction for decades (U.S. patents 2,788,552 4/1957; 2,989,790 6/1961; 4,134,242 1/1979; 4,177,618 12/1979; 4,342,181 8/1982; 4,385,477 5/1983). Testing and field monitoring have long shown that recycled newsprint cellulose fibre as well as other fibrous insulations can readily provide excellent insulation value, permanently, when pumped or "blown" into the enclosed cavites of existing walls.

New construction does not offer such enclosed spaces to contain a pumped fill: the electricals, insulation and vapour barrier work must proceed before the interior finish is installed. The early and recent attempts to overcome this deficiency - to allow the insulation of new wall constructions with dry cellulose fibre - have used rigid, clear plastic formwork or strong open-weave mesh or, most recently, reinforced and strongly affixed polyethylene film. The former is moveable, the latter two stay in place; the last - the most recent - serves as the vapour barrier as well as the formwork. The latter two tend to be costly in material and labour, and tend to allow intrusion of the fibre over the stud face which can interfere critically with the drywall application. The plastic panel method tends to be worse in the latter regard, and has difficulty accomodating irregular stud spacing, slightly bowed or twisted studs (acceptably straight for wall construction), protruding electrical outlets or window frames or cramped working spaces such as in bathrooms and closets.

The cellulose interests had come forward with one more means of reaching the goal: the "wet spray" method. It seems to work well, but has been discouraged or disallowed in Canada because it puts a little more water into the wall cavity, which may already have too much due to the use of wet studs. (The fear, not too well grounded, is that fast close-in with impervious polyethylene film and sheathings will entrap the moisture too long, allowing the wood to rot. At least one Forintek scientist thinks that such is not the case - the cellulose will evenly dissipate any wet spots and act to prevent any rot just where it would begin - but the official discomfort level in such matters is not easily dissipated.) An intrinsic drawback of any wet method is the sensitivity to weather: freezing temperatures and poor drying conditions limit the application season. Nevertheless the wet spray approach remains perhaps the strongest potential competitor to all that follows.

THE CIRCUITOUS PATH TO THE STUDHUGGER CONCEPT

It was a reversal of the foregoing approaches that initiated the present chain of developments. Earl Murray, the dean of the cellulose industry and founder of Regal Industries in Indiana - the largest plant in the world - attempted to meet the glass fibre competition head-on: make better batts, using newsprint cellulose "sausage skinned" in polyethylene film. The epitome of the "farm boy engineer" - a phenomenon given full respect since the Wright brothers - he has equipped the industry with inventions and improvements in fibre manufacture, treatment, automated bagging, palletizing and more. A prototype of his ingenious "battmaker" **(Photo 1)** was brought to Canada for evaluation and acceptance by the National Research Council's CCMC group. The initial Canadian proponents asked the author to help evaluate the prototype, which was designed to be set up on site. Its elegantly simple feed/density control feature worked very well. But the field work **(Photos 2,3,4)** found stubborn limitations in labour intensity, stability during handling, cavity filling and placement, and, less stubbornly, interference with drywall application. Further, the thermal testing at NRC proceeded to yield bad news too: the corner gaps can connect front to back of the wall, convectively reducing the overall thermal resistance much as found with mineral fibre batts. (This, despite the full wrap of polyethylene. Technicians reported that the test installation was particularly poor, and better performance could probably be achieved.)

The Canadian team, disillusioned with the batt concept, decided to try "putting the battmaker in the wall": use the cavity as the form. (Regal nevertheless continued to develop the battmaker for a time, and to perfect their new "Predator" cellulose fibre pump that showed great promise - far beyond the feeding of the Battmaker for which it was initially devised. The latter came to play an important role both south and north of the border.) We decided to work toward the old goal of placing the loose fill fully and firmly in the wall cavity.

Our steps were scarcely straight to the target. The idea of making the cavity into a form does suggest the moveable panel approach, and we obtained the leading example of such a panelized formwork from Seattle. As expected, its rigid aluminum ladder frame (supporting a transparent "Lexan") kept it from fitting closely enough to even slightly bowed studs, but we thought ancillary gaskets or spring pads could correct that fault. They can, albeit tediously or imperfectly, but the other disadvantages of the rigid panel approach proved too much - particularly, perhaps, the inability to accomodate or work around protruding electrical outlets.

Our next step was to develop our own flexible panel system **(Photos 5,6,7).** It featured an array of power screw points to draw it snugly against the studs and plates even where irregularly spaced or crooked, and cutouts and sliding plates to fit around electrical boxes. A modular series of clear polycarbonate plates fitted below windows and in confined spaces. Since we first applied the poly film vb over the whole wall (having foamed in all narrow spaces such as around windows), there was no need to have the cutouts or sliders fit closely around electrical boxes; the poly itself provides the formwork across gaps.

Back in Indiana, Earl Murray's Predator was now well enough developed **(Photo 8)** to provide the high fibre-to-air-ratio feed that the wall systems need; handling a lot of air can require fancy vents, bypasses and filters. The whole system was set up at IRC-CCMC for trials, quickly producing thoroughly insulated walls with uniformly dense cellulose fibre. CCMC "passed" it, pending only the preparation of an installation manual with the usual quality assurance techniques for density, fill completeness and attendant R value.

Our field trials, however, discouraged us from finalizing acceptance; there's no point in certifying a system that insulators won't use. The photos (5-7) don't show much of the real picture: electrical boxes are not at roughly regular heights no matter what the electricians profess; rectangular panels leave considerable areas of wall undone, such as under and over stairs and in closets; the under-window work was tedious; and power screwing is not very fast. We had developed the best panel system, but it's no good; full stop.

But the work did show one thing: 6-mil polyethylene acts as a perfect form in spanning small gaps. Ian Platts became stubbornly intrigued with this, and with his idea that it should be feasible to make it do the whole job - after all, it has to cover the whole wall: cavities big and small, rectangular or oblique. He ventured to make a rough mock-up to try his unique clamped-poly idea: a "stud hugger" stanchion to hold the film onto and slightly around the stud, pulling it as taut as a drumskin to retain the pumped fibre at adequate pressure and density without too much bulging of the film or intrusion of the fibre between it and the stud - both of which would interfere with drywall application. The mock-up worked.

Encouraged, Ian ventured much further, building a full set of "working mock-ups" to allow trials on full wall sections. These stud-hugger stanchions **(Photos 9,10,11,12)** featured a temporary top channel and a foot lever to jam them in place, and a bowed design to apply uniform pressure against the full height of the stud **(Figures 1 and 2,**

from Patent Application 2,097,849, Ian Platts, 1993/08/05). The set also included clear poycarbonate shields to clip onto the stanchions and help support the poly when needed - with studs at 2 ft. spacing, for example **(Photo 11).**

Two "proof of concept" trials served both to dash hopes and sustain them: the crude system failed, the concept worked. In the first, an Ottawa house provided by Coscan, the stanchion mock-ups appeared to work but the early model Predator blower - and a commercial truck-mounted blower - failed to provide the required pressure control and high fibre ratio without stalling or jamming the blower hose. The second, on a North Bay house following Regal's final development of the remarkable Predator, was somewhat more encouraging on the studhugger capabilities but still failed to produce cellulose insulated walls, as is discussed below.

Regal Industries continued to advise and encourage all the following Canadian efforts as well, and finally gave up on the Battmaker and partnered fully with the Canadian team. That, and the timely support of the **"H-TIP" R&D program** (the Housing Technology Incentives Program of the Canada Mortgage and Housing Corporation) enabled us to complete the next steps and develop, finally, a wall insulation method that works.

DEVELOPING THE PROTOTYPE STUDHUGGER STANCHIONS

The earlier trials with the mock-up stanchion had met with problems of containing the pressures developed in pumping the stud cavity full of cellulose fibre to the necessary density of 2.8 - 3.0 pcf. (Work at Oak Ridge Laboratories has shown that such a density assures no settlement of dry fibre, removing any need for adhesive or other treatment that raises costs and introduces moisture into the wood frame wall; NRC/CCMC has confirmed those findings.) The stanchion had been bent away from the stud in its middle third or so to the point where fibre would be blown in and lodged between the polyethylene and the stud face, interfering with subsequent drywall applications. Where not sprung away - near the anchored top and bottom - the stud hugger stanchion worked well; that in fact constituted the essential and only "proof of concept" of the mock-up period.

Furthermore, in the trials, the anchoring methods proved slow, particularly in the temporary mounting of the top channel, and the grip of the bottom lever was tenuous; the mock-up system was not a satisfactory prototype of a working system in these respects.

The trials had also failed to isolate the variables in play: fibre/air ratios and pressures of the two types of blower in various conditions, modes, and feed adjustments and under indeterminate operator skills; settings of jury-rigged air bleed valves at the blowers; pressure relief with effective dust control via various exhaust port/filter arrangements at the pump-in port and elsewhere; indeterminate relief at the stud/sheathing interface and through the studs at wiring holes; variable stiffnesses and cambers of the mock-up stanchions as well as, of course, the straightness of the studs themselves; and the effect of different makes and conditions of fibre.

Accordingly, the new design/development program was pursued systematically in four streams, more or less in parallel: 1) develop fast and reliable anchoring methods, and try to develop stanchions and anchoring that can accomodate the common variations in stud heights in a house (eg., basement, garage, and stairwell as well as the normal storey condition); 2) determine the range and "worst case" pressure and containment requirements; 3) determine the tolerances and final stiffness requirements; 4) determine material properties and choices to suit available fabrication facilities as well as lightness, ruggedness and tailorability for trials. With the requirements adequately determined, the final steps were to design and develop the stanchion and "hugger" pad accordingly, while letting the blower developer, Regal Industries, determine its optimum design and operating parameters and feed the characteristics into the progressing work on the stanchion and the full system. In all of this, the intent was to move methodically, at last, to present working prototypes that would handle and perform like production models, to the industry's satisfaction - the industry as represented by our partner, Regal Industries. The path was now visible, if not easy.

Anchoring Requirements

The anchoring concepts initially sought to leave the polyethylene intact - but that is an academic point since the blow-in port breaks the poly and demands patching in any case; perforation for anchoring is acceptable if it is within the port area that must be patched.

Observations on house construction in much of Canada suggest that the use of ceiling furring (strapping) is a commonplace, on both first and second storey ceilings - for whatever reasons may be imagined but economy and utility do not spring to mind. The strapping does, however, offer a good anchorage at the top of the stanchion: an opportunity to do away with the time-consuming installation and removal of the aluminum channel used in the mock-up system. At the same time, the force required to sink teeth into the strapping can best be provided by modifying the mock-up's foot jack to lift up as well as push in, and that in turn helps to sink its teeth in to the subfloor and keep them sunk - securing much more reliable anchorage. The teeth and the setting forces and mechanisms must be designed to withstand that, with a working margin allowing for variations in subfloor and furring hardness and springiness as well as tolerances in the standard distance between them. **Photos 13 & 14** show the half-height mock-ups built to prove and refine this approach.

(The accomodation of non-standard ceiling heights, unfurred ceilings and concrete floors was left at this point to supplementary power screws, as in the earlier mock-up work; these are seen in the Fabrication illustrations, below.)

Load/Deflection Requirements

Pressures and loads: The loads and equivalent pressures were measured on a simulated stanchion section, a test frame, with the hugger pad compressed to the known range of effective deformations (as earlier observed in the successful portions of the mock-up stanchions). The pressures were compared back to the range developed by the Predator blower in its earlier and final developmental stages. **Photo 15** shows the test set-up.

Allowable deflections and stanchion stiffness requirements were then determined in conjunction with the "hugger" pad design and compression tolerances in maintaining the required containment pressure over the full height of the stud.

"Hugger" Requirements: The foam hugger pad has to apply the required fibre-containment pressure to the polyethylene against the stud, while forcing the poly partly around the stud to draw it tight enough that its residual bulge-out between studs (with the stanchions removed) will be acceptably slight for the drywaller. It must do this well enough while accomodating the usual positive or negative bow of the stud and the bending of the stanchion itself under load.

Finally, the hugger cannot simply "play safe" by pressing harder and pulling the poly tighter: that requires an unduly stiff and heavy stanchion and also forces a crimp profile in the poly that keeps the cellulose from filling snugly against the stud right to the front edge. While the resulting thin, shallow "dead end" gap does not reduce the R value, it looks bad, suggesting more of the contentious batt image rather than the full-value cellulose fibre image and reality that is a driving force in this development venture. This bit of cosmetic control is given critical attention.

The method and apparatus shown in **Photo 15** was used to explore various hugger materials and configurations concurrently with measuring effective loads and pressures. The proper profile of the polyethylene around the stud is sketched full-scale in **Figure 3**.

Design of the Prototype Stanchion

Following a few iterations on paper, the schematic shown in **Figure 4** represents the first thinking for "normal case" stanchion mechanics ready for mock-up and test. The configuration of stanchion, hugger pad and hardware has to allow: a) pushing the top against the stud/ceiling corner with the hugger compressed to a stopped thickness of 0.5 - 0.75 in.; b) holding it there while positioning the foot jack, which must c) try to lift the stanchion a further 0.25 in. while positively pushing it a further 1.5 in. toward the stud; and d) locking it in place by securing the top of the foot jack.

The half-height mock-up and test frame mentioned earlier (photos 13 & 14) afforded good trials of the concept. Varying the height of the test frame +/- 0.1 in. showed the need for a spring mount for the fulcrum/cog which, in combination with a practicable range of penetration in sinking the top and bottom teeth, can accomodate variations in room height of 0.25 in or slightly more. (The almost universal use of precut studs seems to keep the standard height within such bounds.) The provision of a hard rubber seat - made in this instance from inner tube layers - completed the half-height mock-up work ready for design to begin on the working prototype stanchion.

Stanchion stiffness: As noted earlier, achieving the critical pressure to push the polyethylene against the stud, and to crimp it to a fairly critical profile around the stud, depends on the elastic properties and proportional compression of the elastic "hugger" foam. The actual compressed thickness at any point - i.e. the distance from stanchion face to stud face - will tend to be maximum at center height, giving the minimum compression and force against the poly/stud, and is the resultant of: the initial bow of the stud toward or away from the stanchion, which can be expected to reach 0.2 in. fairly commonly; the bending of the stud under the imposed load (an appreciable amount with a 2x4 stud - up to 0.2 in.); the initial bow of the stanchion toward or away from the stud, which is a material/fabrication issue; and the bending of the stanchion under load away from the stud, which is a matter of load and design stiffness, to be determined in conjunction with the hugger pad design and overall weight, ruggedness, compactness and cost factors.

While these seem to comprise tough design requirements for a lightweight, uniform-section stanchion - which could be eased by making the hugger pad still thicker and thus more tolerant, but that's not desirable - it's not so rigorous because the load/deflection is self-limiting: The more the stanchion and stud bend away from each other the less the load trying to bend them. Analysis of the non-uniform loading, for the geometry and stiffness range of concern here, produced the required stiffness value EI and guided the prototype design and consttruction.

Stanchion material: A rugged, lightweight working prototype could be made of GRP (glass-reinforced plastic), aluminum, wood or combinations of them. The first is difficult to hand-form, or ultimately to set up for limited-volume production; the second is also difficult to fabricate in a small shop and modify as trials progress (but it probably would be the material of choice for final system production); the third is scarcely available these days in clear, high-modulus stock that is straight and will stay so - but its "reconstituted" derivatives offer precisely those qualities. The "parallel strand lumber" products appear almost ideal in every way, except that they are not yet available as small section stock and their manufacturing process can not readily offer the shaped sections that should be the base stock for efficient final production. For present purposes, however, MacMillan Bloedel's Timberstrand was first selected (elastic modulus E of 1.8 million); it not being available in eastern Canada, their coarser but even stiffer Parallam was chosen (E of 2.0 million).

Stanchion design: The stanchion section shown in **Figure 5** met the stiffness and strength requirements almost precisely, and does more: The overall dimensions allow exactly four pieces to be sawn from one standard 3x12 (2-7/8 x 11-7/8) beam, with perhaps a residual thought at the time that the material might be suitable for full-scale production of final stanchions. (While three stanchions are perhaps enough for test purposes, 4 or 5 are much preferred for full trials in that they provide fully tightened poly on the cavity being filled along with tightening support from the poly on the adjacent cavities, and they allow the stanchion's "leapfrogging" to stay well ahead of the insulator.)

The H section and tapered ends retain stiffness while shaving a third off the weight (18.5 lbs whittles down to 10.5), and the side slots are proportioned to secure the arms of the transparent shield, if it had to be carried over from the earlier mock-up work to support the poly over the middle of the stud cavity; they also afford a groove in which the foot jack is secured for transporting the gear from job to job. The ends of the stanchions were left solid to receive the top and bottom hardware and to allow for modification during testing and trials.

Fabrication

A jig table was built to assure straight and accurate shaping of the four stanchions, **Photo 16.** Section control and particularly height control (the distance between the fulcrum and the tip of the top teeth) were set at +/- 0.05 in. While the coarseness and allowable strand packing variations in the Parallam manufacture called for a great deal of tedious filling and patching - in this already time-consuming hand prototyping - the production went well and the final product met the design criteria as a straight and rugged "chassis" receptive to the hardware and amenable to modification.

First Tests and Modifications

A test frame was constructed to represent a floor-stud-wall section, allowing the insertion of various subfloor materials and grain directions as well as ceiling furrings. The first trial of the new stanchion showed the need for a spring toe support to keep the top teeth adequately set until the jack was levered and secured. A rubber toe, **Photo 17,** was concocted of inner tubing over compressed foam rubber. It worked well at first, but a few dozen cycles scuffed the rubber casing and fatigued the foam. A spring-loaded hardwood toe was slotted into the stanchion to replace the rubber, worked very well indeed, and was fitted to all four prototypes, **Photos 18 & 19.**

The mounting tests on the test frame, **Photos 20 - 23,** consistently showed that the stanchion and its gear exert the proper compression and force. With the foot jack secure in its work, **Photos 21 & 22,** and the top and bottom hugger zone compressed to the design point, the stanchion deflection measured close to the calculated 0.13 in, **Photo 23.** The stanchion could be removed and re-mounted to hug the next stud in about 10 seconds. The prototype stanchion appeared to be complete, ready for full-scale trials and perhaps demonstration - and this point marked the beginning of real evaluation and refinement of what was supposed to be a model of a ready-for-sale system.

TOWARD A UNIVERSAL STUD-HUGGER SYSTEM

The proposal to HTIP envisioned the modest intent of the time: develop the stanchion to handle the full-height wall studs, and also fit over windows to handle the cripple studs below, so that perhaps 80% or more of the wall area of a typical house could be pumped full of cellulose. The idea then was that the remainder of the wall areas would first be carefully insulated with rockwool batts, and the window frames and very arrow cavities filled with the better polyurethane foams as now available, prior to applying the polyethylene air/vapour barrier. The "common sense" batt idea seemed to conflict somewhat with the ideals of the new concept, and naturally did not sit well with the cellulose people.

Further, the idea had been to develop an installation method and gear for the typical Canadian house with furred ceilings at regulated height; there was no clear idea in mind for unfurred ceilings or varied heights, or for concrete basement floors, save one: the power screw method - a fallback which had worked well, with what seemed like reasonable speed, in the mock-up trials preceding this work. Provisions were made for these screws as shown in **Photo 26.** Again, the appealing speed of the toothed top anchor gear, coupled with the realization that much of Canadian and most of American house construction does not throw convenient furring into the equation - and certainly Regal's wistful musings over the 'phone that something like toothed gear had to be made universally operable - all of this left an uneasy feeling that the Stud-hugger Stanchion was not yet the complete Phase 1 system it was meant to be.

Full-scale trials now seemed appropriate and timely to help learn where we were and how far we could go. Since the Predator pump developments were complete and the second generation machine already in wide use in Indiana - and Regal was suggesting that its performance might change some of our elaborate thinking on air control - it was decided to ask Regal to help with such a trial in their area, Crothersville, Indiana.

Earl Murray, the founder of Regal industries and dean of the cellulose insulation industry, arranged with a nearby housebuilder to try the new system - bypassing any further shop trials altogether. The stanchions passed through the obliging US customs and, by way of Mr. Murray's home and adjacent Lakeside Lab (**Photos 27 - 29**) right onto the Seymore, Indiana job-site, to a full developmental trial that was ideal in every way - save for its 909-mile distance from Ottawa.

The Regal team included Mr. Murray and design engineer Ralph Sweeney (**Photos 26 & 27**), and principal salesmen and supply people; Platts brought the stanchions and was able to stay through three days of yeasty trials and refinements. These quickly brought the stanchion development to the point of a demonstrably successful working prototype, marking the completion of Phase 1 as envisioned - but went on to suggest substantial improvements to the moveable stanchion stud hugger gear:

- The stanchion was readily secured in place using the top screw and the bottom foot jack; the spring seat in the cog was able to accomodate the lift geometry. The power screw operation was slow overall, with the awkwardness of needing a stepstool. The foot jack teeth had to be reshaped a little to bite reliably into the hard "waferboard" subfloor.

- The Predator filled the 2x4 stud cavity to 3+ pcf density in just 22-25 seconds - which delighted the team with the realization that a 2-person crew could insulate a house in half a day if the power screw could only be replaced with a toothed anchor. The speed potentials teased everyone. A short piece of furring was temporarily tacked in place to demonstrate the convenience and reliability of the hinged top teeth.

- The new Predator rather completely overturned our Canadian experience and sorely-studied approaches regarding the need for a filtered exhaust port, to a) bleed off the excess air, and b) to use in a one-point filling technique to control density by choking off the exhaust filter at intervals. The Predator's fibre/air ratio has become very high indeed; the exhaust port is not really needed and the air bleed is so slight that choking it has no effect on cavity pressurization and cellulose densification. In fact, Regal's competing Battmaker venture had shown those points, and helped confirm that the old technique of inserting the hose to the bottom and then the top of the cavity still affords the best combination of contol, speed and snug filling behind electrical boxes and wires. It was re-adopted, and matched the filling speed of the top one-point filling while avoiding the need for climbing off the floor.

- The top screw was now left as the single, sore point requiring such climbing. Regal devised inverted claws to anchor the top: a set of chisel-toothed fingers to reach in neatly under the top plate and bite into its underside - but puncturing the poly, unfortunately. (As it happens, this position can be covered easily by the overlap of the ceiling poly or flapdown of wall poly.) As shown in **Photo 30**, the fingers were quickly made and installed back at Lakeside. Later they were made retractable to afford safety in handling and to accomodate corner and double-stud application.

The fingers worked very well, and the team proceeded on the regular-height wall areas, **Photo 31**. The hugger pressure and profile and the speed and control of the system were now all working as planned, and this point seemed to mark the end of the the "working prototype" stanchion system development, ready for full demonstration.

The standard-height walls marked no end, however, for the Regal and Scanada inventors who now had a foretaste of the kind of success that the cellulose industry has long sought. In finishing this first house, problems continued to arise and be met with a flood of ideas that revamped and finally superceded - or created a preferred alternative to - the moveable stanchion type of studhugger. The major problem: the house, seemingly a straightforward bungalow on a PWF basement, presented three different "regular" ceiling heights, not to mention the usual short studs and stairwell longs; much of this made the dependency on precisely spaced anchor teeth look silly. The power screws work well and are fine for the odd case, but are too slow for large areas. The team proceeded to devise concepts for extensible stanchions and various grabs, including a stud-grasping, variable length stanchion, a departure indeed from the fussy end-anchored prototype; and an extensible hinged-jack concept. **Figures 6 - 8**, show much of this work. (The stud grasp "ice tongs" pincer had been dismissed in the original conception and mock-up work to avoid penetrating the poly, but that's okay at mid height where the hose port has to be patched anyhow.) Rough mock-ups showed that these can work, but complexity, fragility and costs are increased.

THE "CUPPED BATTEN": THE UNIVERSAL STUDHUGGER

Two further problems marred the performance of the stanchion/film formwork system in the Indiana trial. One was peculiar to the house design feature of a cathedral ceiling: Not a rare feature, these are not readily served by any type of stanchion, although the centre pincer rig could work, if awkwardly. That, and other awkward areas, got Earl Murray thinking about a fixed studhugger strip that would be an adjunct to the moveable stanchion.

The second problem was potentially more critical: When the stanchion sets are moved along, the polyethylene slackens; the cellulose column generally remains stable while awaiting full support from the drywall, but the nailing of siding before that can dislodge some of the fibre to intrude between film and stud to an amount that interferes with easy drywalling - and can sometimes make the unsupported column of fibre settle away from the top plate.

Nothing like that had happened during the North Bay and Ottawa trials, which included short periods of hammering the studs. But the application of siding after the insulation but still before the drywall - not a usual sequence but there's nothing to stop it in dry regions or seasons - proved to be a much stiffer trial, and the system was found wanting. Suddenly, the idea of fixed strip studhuggers move up to compete with or supercede the moveable stanchion, rather than simply serve as an adjunct to it. The project turned a corner.

The cupped batten: A fixed strip or batten studhugger has to do the same job as the stanchion in pressing the film inward and drawing it taut; much of the foregoing work on pressures and profiles still applies. The batten must be of a calculated stiffness across its width, must accept stapling and then the drywall screws, and must be thin enough that no depressions are visible in the drywall where it covers unbattened areas of framing. And it must be cheap - perhaps not more than $0.03-0.04 per foot to the tradesman - because it remains in place as an additional cost burden. The test rig of **Photo 15** was used again, this time to explore the adequacy and workability of thin cupped batten strips in forcing the polyethylene into the profile while being applied with the normal stapling that the poly needs in any case.

Prototype development: Two materials appear suitable: moulded cellulose fibre, or laminated paper which is essentially the same thing; and extruded polyethylene from low-grade recycled stock.

The extruded poly is probably the ideal in cost, resistance to water and site conditions generally, and amenability to packaging in rolls. The cupped profile would flatten in forming the roll and spring back when forming the straight batten of whatever length, just like a steel measuring tape. The poly could creep, however, losing some of its profile set; nested straight strips might be best, handled in a quiver.

The working choice for prototype trials, however, had to be the moulded cellulose fibre. An old "high-tech" product proved to be just the thing: spiral-laminated paper tubing. It was developed by the paper industry many years ago as the inexpensive axle to roll paper into huge rolls directly from the paper formers, and to mount them directly on newspaper and other printing presses. A Canadian development, we think, the tubes are themselves formed from mill scrap paper (accruing from start and stop operations, tearing and splicing, and flawed areas), using a cheap adhesive such as sodium silicate for the spiral roll laminating at high speed. The predominantly circumferential lie of the fibre is ideal to offer the stiffness in thin sections that the cupped battens need.

Three inch OD industrial tubes were cut into one-third circle as well as some semi-circle sections as working prototypes. These worked well on the test rig in Ottawa, the third-circle size behaving best in stapling and profiling/tightening the poly film just right. Some of each size were nested and packaged in a 6-in tube, **Photo 32**, and couriered to Indiana.

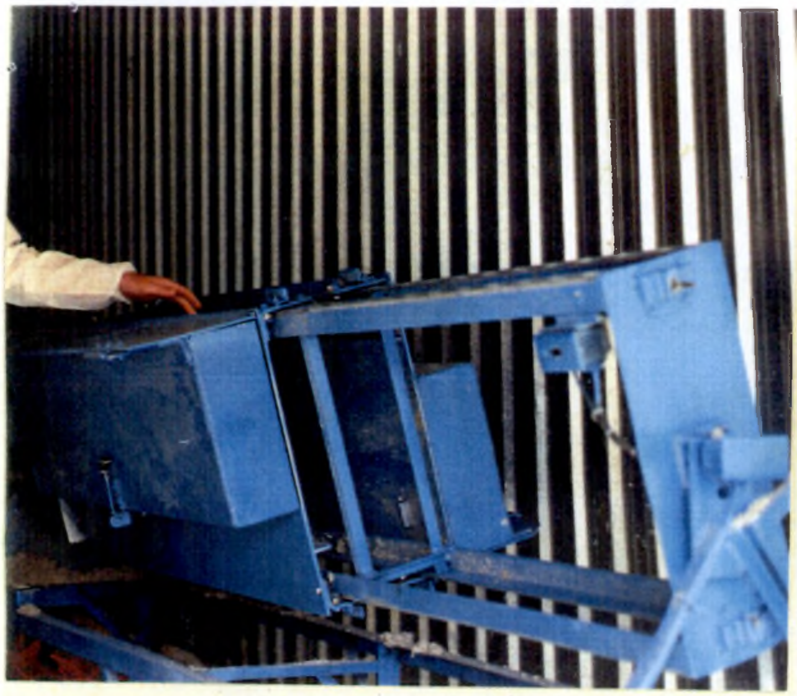
Regal set up a test wall and proceeded to try the new studhugger idea thoroughly, **Photos 33 - 43**. The Predator blower was used, of course, with top and middle variations of the cavity feed and with some new air-relief vent devices. These proved to be unnecessary: normal leakage accomodates the remarkably low air/high fibre output from this cellulose pump, **Photos 34 - 38**. The trials used the heavy 6-mil polyethylene as presently required in Canada. Regal's engineer Ralph Sweeney designed the test wall for repeated testing with a single application of film and cupped battens, with trap doors in the sheathing to allow the cellulose to be cleaned out between trials, **Photos 39 & 40**. Such removal, in addition to hammering the wall to try to settle the fibre, proved its ability to stay in place - **Photos 41 & 42**. (Photo 43 is brought forward from the earlier work in North Bay with the panel-type former, reinforcing the demonstrated stability even where some fibre has been removed. The brown cellulose is "corrugate" - excellent fibre recycled from cardboard boxes.) Finally, simple trials such as in **Photo 43** confirmed that neither the battened stud condition nor the film bulge interferes with the application of drywall.

CURRENT DEVELOPMENTS

The team has kept the patent applications up to date in both the USA and Canada, adding the cupped batten as well as the extensible stanchion and centre-grab improvements to the original concept but keeping the lineage appropriately. In the meantime, Regal has developed and protected a separate approach which may well be more widely competitive in the USA, where polyethylene film is not broadly required: An inexpensive mesh is instantly adhered to the studs - which can be steel - with a no-sleaze fix that practically eliminates bulging. Such bulges, and the problem of excessive dust usually associated with mesh-form systems, are further minimized by the low-air attributes of the Predator pump.

This parallel system work is also suggesting that the cupped-batten/poly system, mated with the Predator, can work with just 4-mil film. That makes it more competitive where 6-mil is not required, or no poly for that matter; that more rational state may again return to Canada. Builders who wish to claim extra quality may well wish to continue with polyethyene and feature the cupped batten approach; others can offer excellent results with the new mesh system at comparable or perhaps lesser costs. Regal has now costed the new family of cellulose wall systems, and they certainly appear to compete well against mineral fibre batts while offering better thermal performance and, of course, the proper use of recycled "wastes".

The Canadian part of the team now includes an industry scientist partner, and is poised to sign up industry to launch the cupped batten system with extruded plastic. Rights to Regal's new mesh approach are also extended into Canada. Finally, it has to be said that Regal Industries' energy, astuteness and integrity has been pivotal in moving this sometimes tenuous and amateurish quest into a promising North American venture.



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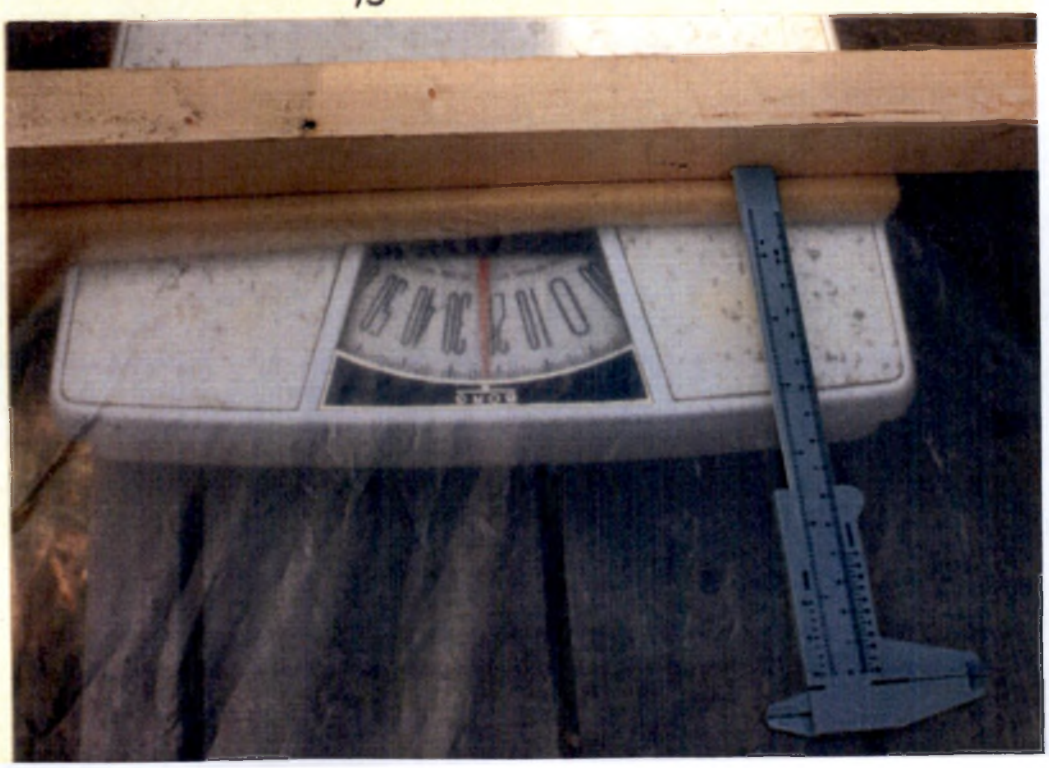

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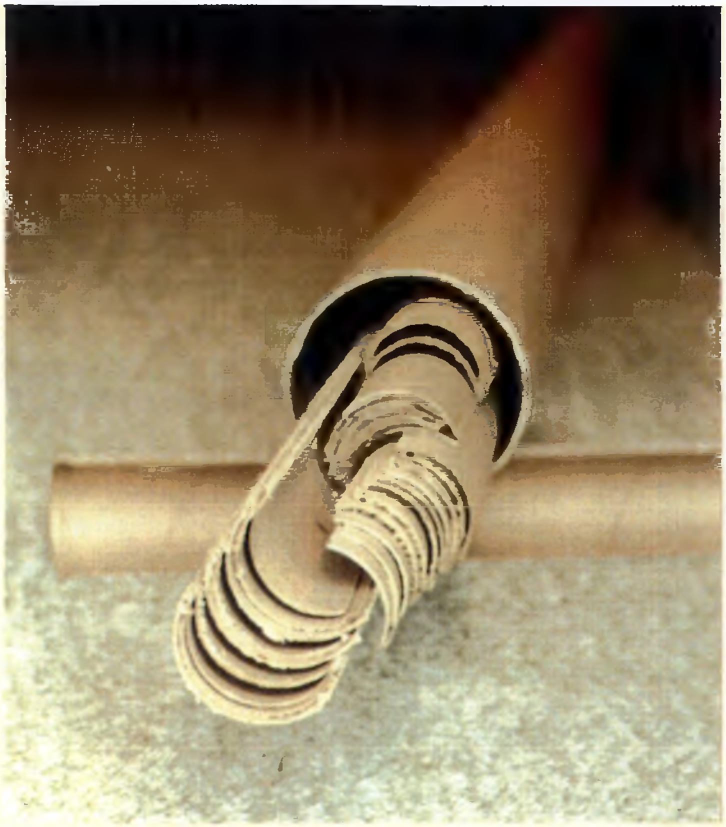

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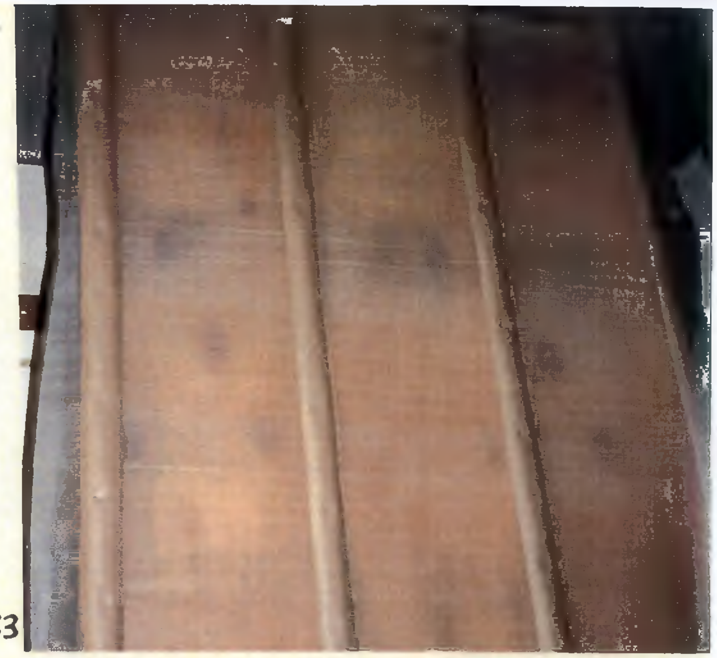

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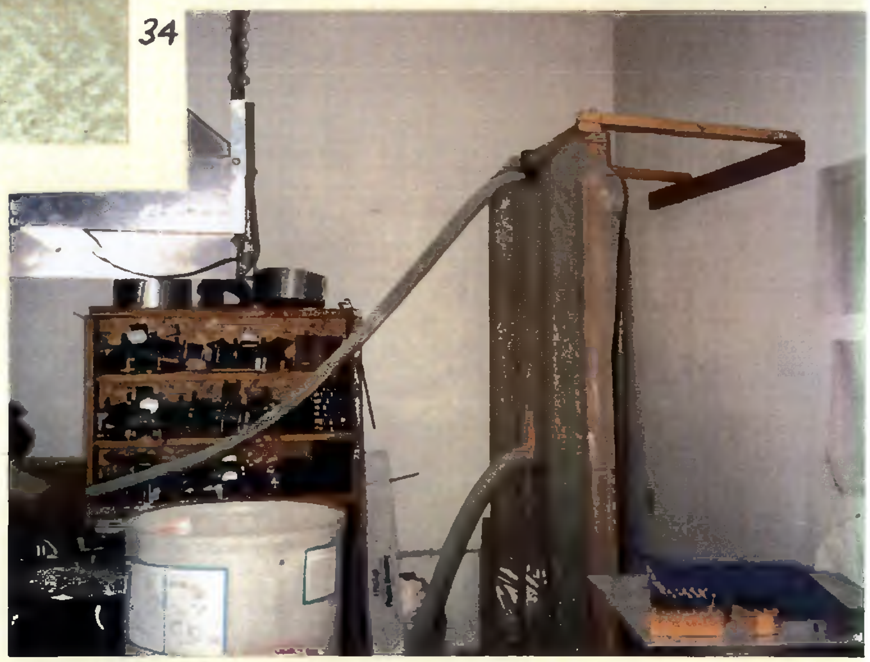

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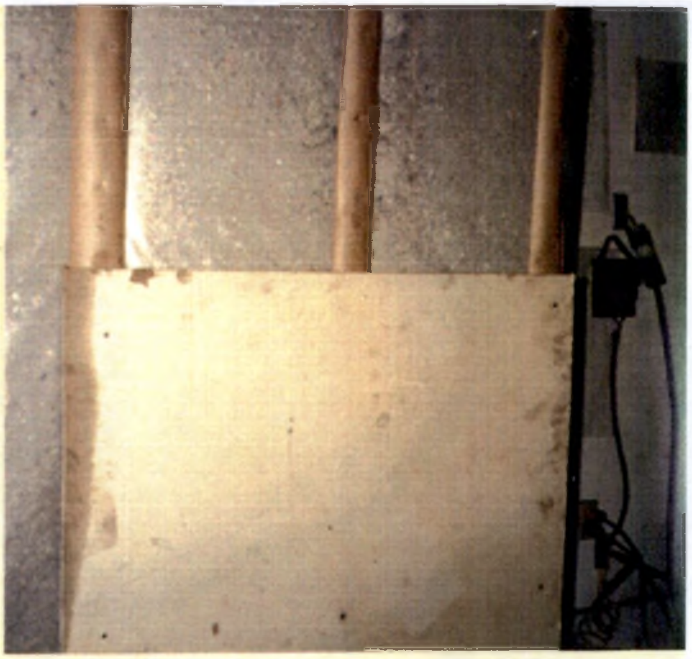

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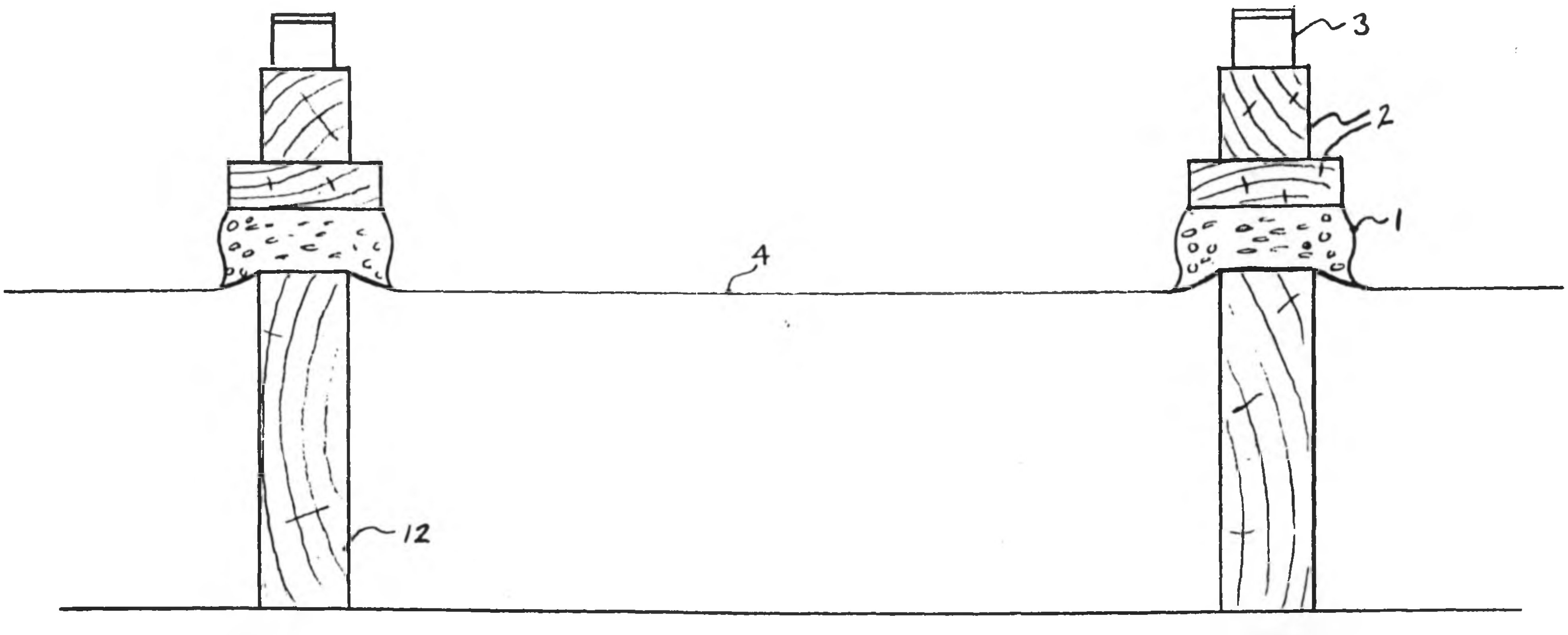

Fig 1

4 Aug 93

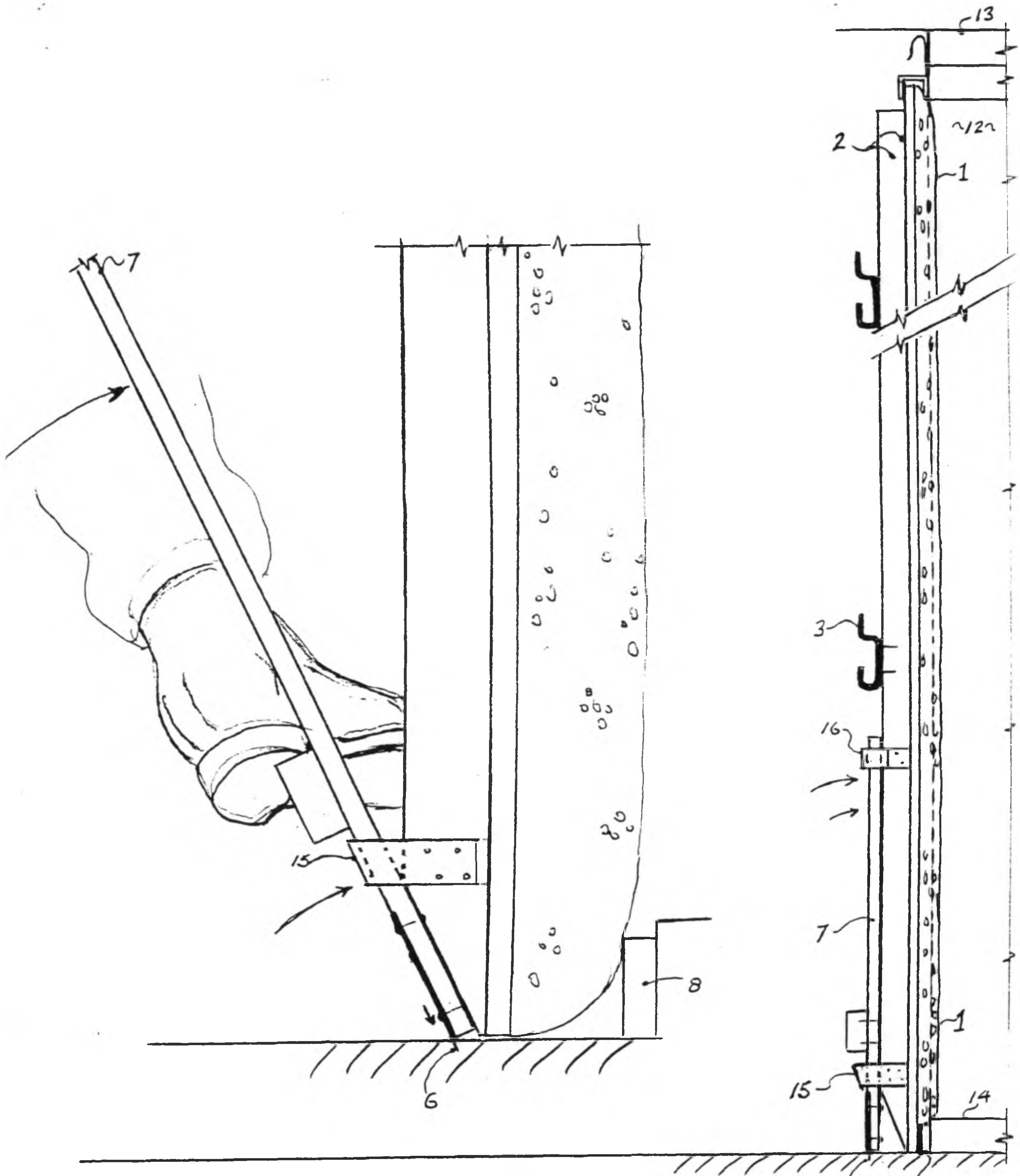

Fig 2

4 Aug 03

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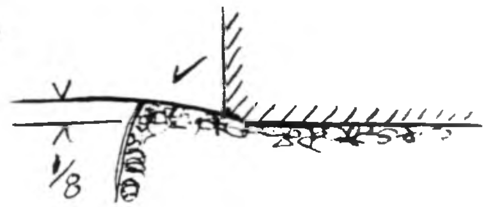
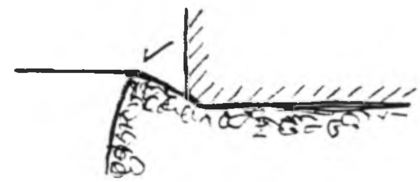
B. Poly tighter – sagging 1/8 in over 16 in span

Test B-1	Net Load-lbs	Comp to	Profile
(repeat 1) 2" deep 2 1/2" wide	(Same, roughly)	3/4"	

Test B-2			
(repeat 2) 2" 2 1/8"	30 lbs	3/4"	

– Wider, tighter yields better profile

Fig 3 Poly Profiles from test rig Photo 15

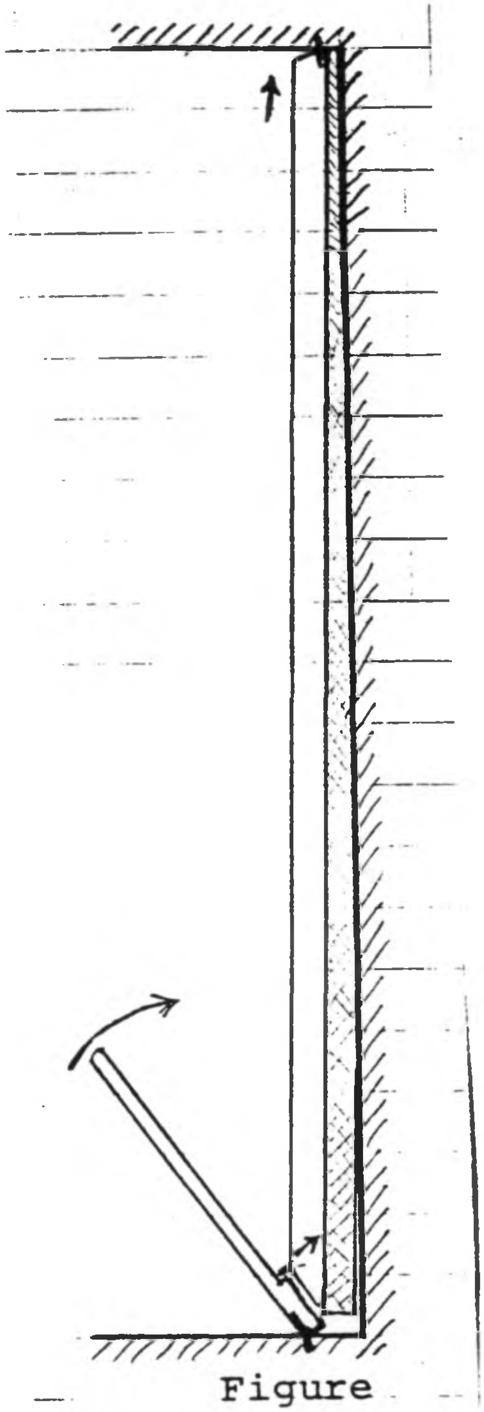


Figure 4

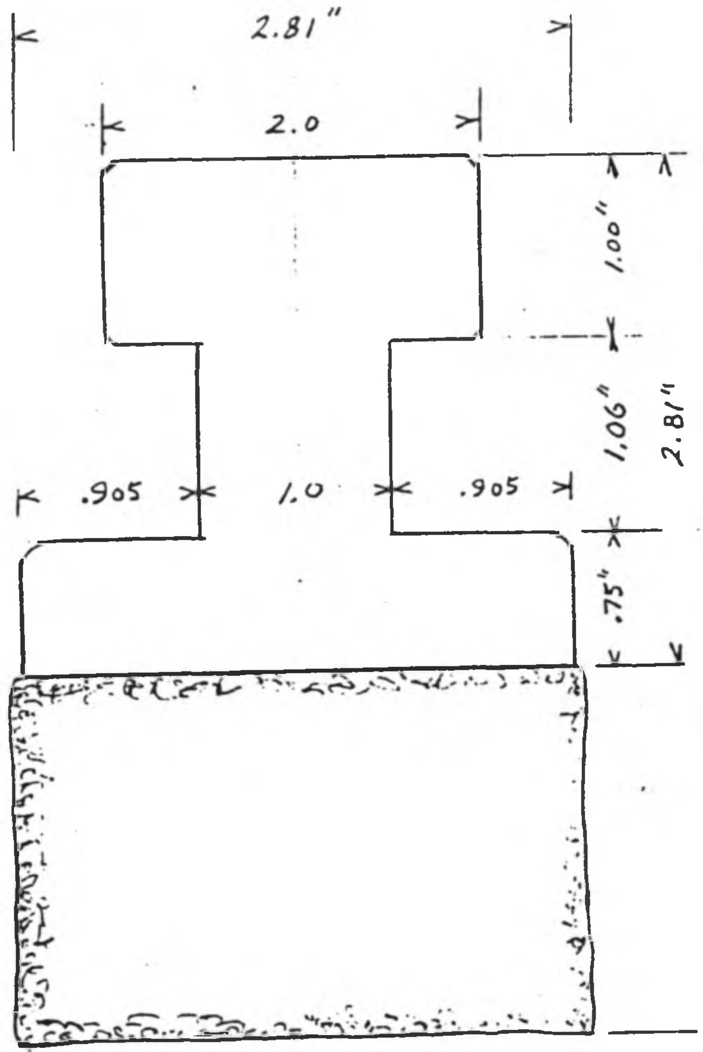
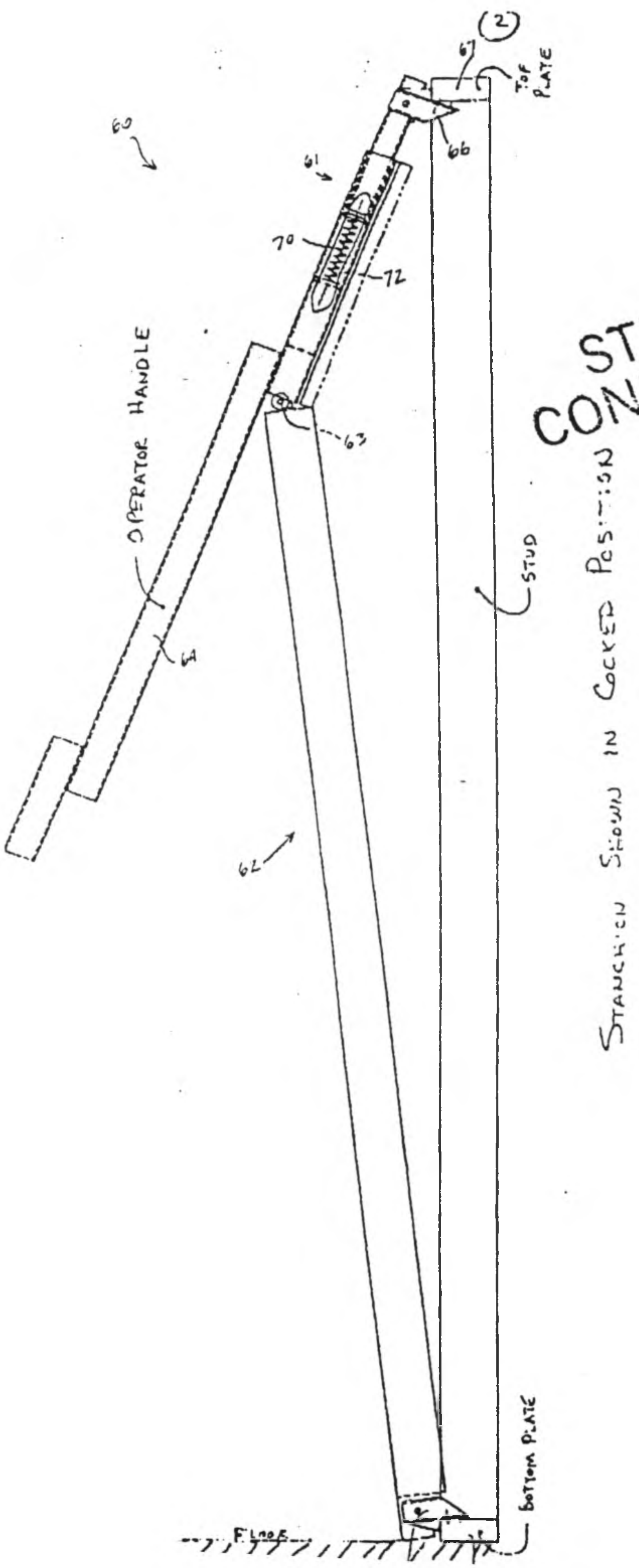


Fig 5



(2)
67
TOP PLATE
66
60
61
70
72
OPERATOR HANDLE
63
64
62
STUD
STANCHION SHOWN IN COCKED POSITION
BOTTOM PLATE
FLOOR

Fig. 6

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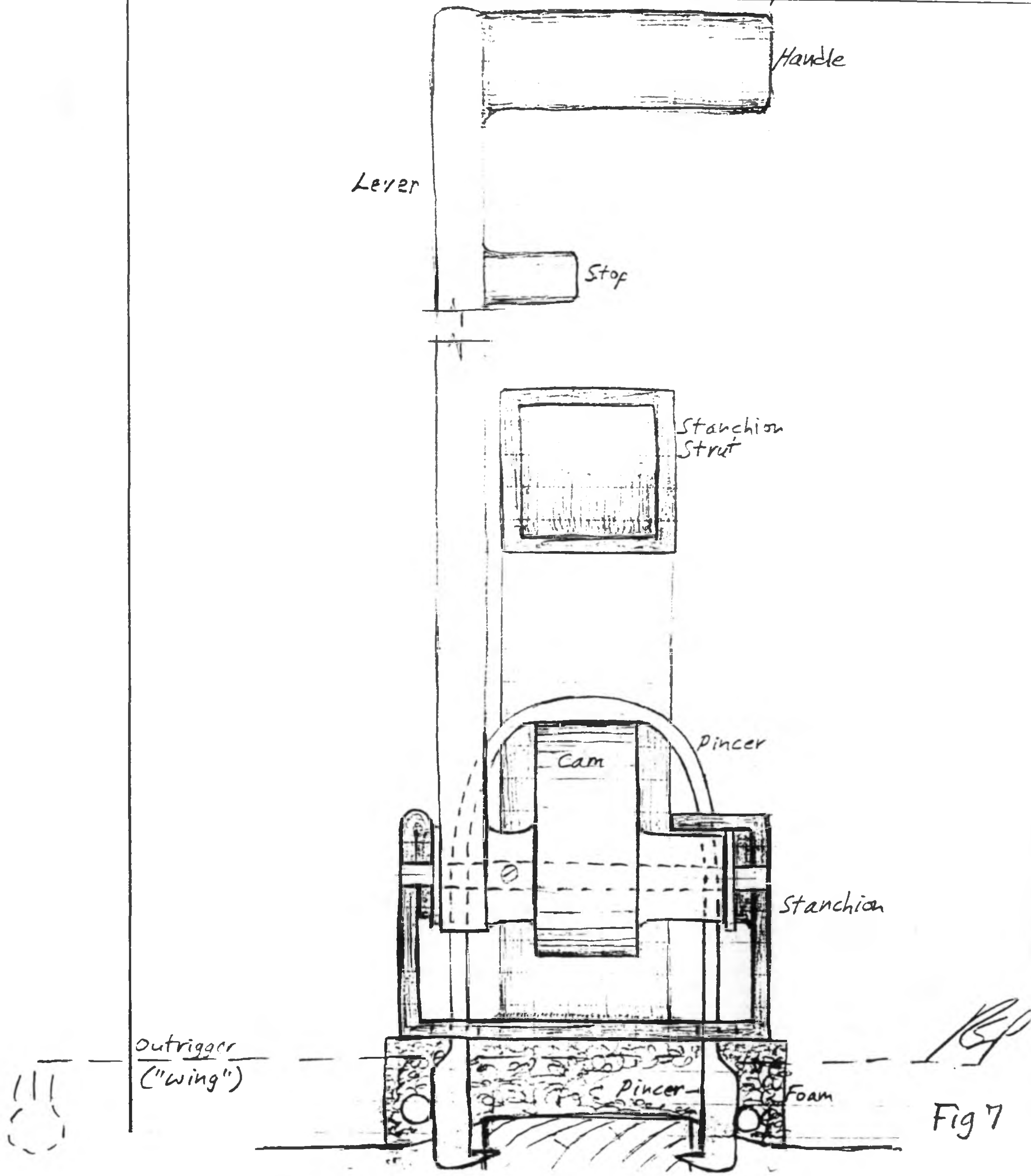

Fig 7

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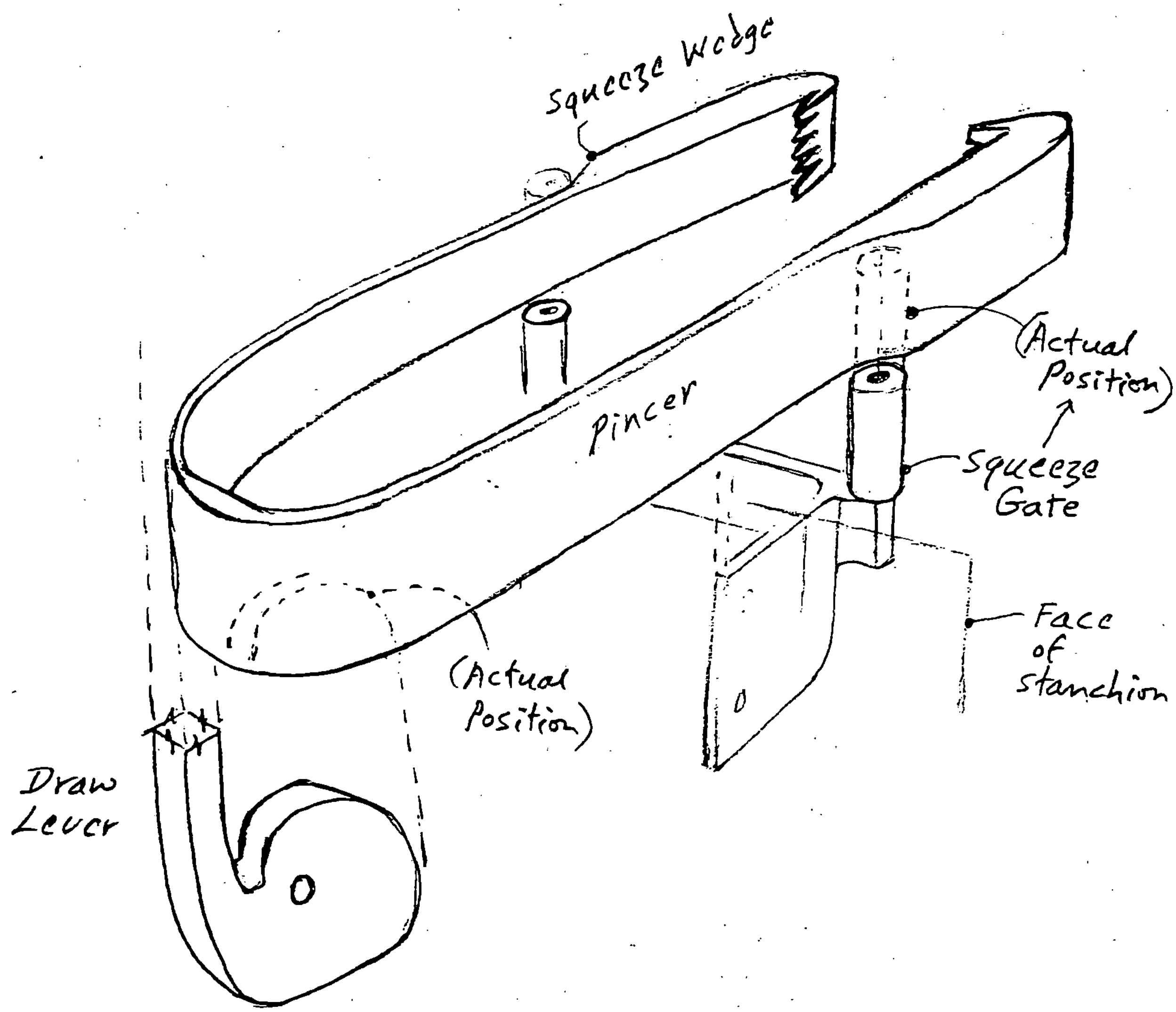
Job. No.: S9305 Ext	Job Title: Centre Pincer VGHSH 3	



RSP

Fig 8