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TECHNOLOGICAL STUDIES OF THE CODWORM (PHOCANEMA DECIPIENS) PROBLEM

by
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Abstract

Results of some contract studies on temperature tolerance of codworms and some new detection techniques are reported.

(1) Acoustic microscopy. The short depth of sound penetration and the small sample size scanned are limitations which, together with the high cost of the equipment, are reported to preclude the use of this instrument for codworm detection.

(2) Fish plant freezing experiments. All codworms subjected to normal plate freezer processing and/or frozen storage in two commercial fish plants were killed by the processing procedure.

(3) Codworms in fish samples cooked in any one of six conventional cooking procedures wee killed when cooked as recommended (10-12 minutes per inch of fresh fillet) and checked for "doneness" or completeness of cooking.

(4) Laboratory freezing experiments showed worms in situ in cod fillets are killed when their temperatures reached 10°C. Exposure of worms to 60°C killed the parasite in four seconds.

(5) A candling table in which the fillet is placed between two polarizing filters, polarized at right angles to each other, produces an effect in which the fillet appears bright against a dark background and thus reduces eyestrain and fatigue.

Résumé

Les resultats l'études faites par contrats sur la tolerance de température du ver de morue ainu que quelques techniques nouvelles pour détecter les vens sont rapportées.

(1) Microscopie acoustique. La penetration du son d'une propandeur limitee ainsi que les petits échantillons à scruter sont des limites qui avec le haut coût de l'équipment empûhent l'emploi de cet instrument pour détecter le ver de morue.

(2) Les experiences avec l'équipment de congélation des usixes de poissons. Tous les vers de morue qui ont été soumis aux procédés de congélation ou à l'entrepasage de congélation dans deux usines commerciales de poissons furent tués par le procédé.

(3) Les vers de morue dans les échantillons de poissons cuits dans n'importe lesquels des procédés de cuissons conventionnelles furent tués quand cuits comme recommandé; 10-12 minute par pouce de fillet frais ainsi que vérifier pour la cuisson à point.

(4) Les experiences de congélation dans le laboratoire ont demontré que les ver de fillet de morue in situ sont tués quand la température atteint 10°C. L'exposition des vers à 60°C les tue en quatre secondes.

(5) Une table à mirage dans laquelle le fillet est placé entre des filtres polarisés à angles droits l'un a l'autre a donné un effet dans lequel les fillets sont brillants contre un sombre arrière et ainsi réduit la fatique des yeux.

The codworm, Phocanema decipiens, a nematode parasite of fish, continues to be a problem to fish processors. At a "codworm workshop" reported on last year (Odense, 1979), consideration was given to biological and technological solutions. It was determined that the only effective biological solution would be a significant reduction in the grey seal herds. Until this is achieved, the onus remains upon the fish processors and fisheries scientists to devise better methods of worm detection and removal, and to ensure high standards of quality control.

Some of the early results of some contract studies to reach the above goals were described briefly in last year's report. These contracts included a study of the feasibility of using acoustic microscopy for worm and bone detection, a study of lower and upper temperature tolerances of codworms during processing and cooking respectively, and the construction of a candling table using polarizing filters to reduce eyestrain. For the most part, these contracts have been completed and some of the final results are summarized in this report.

1. Acoustic microscopy.

Drs. C. Watts and L. Russell of the Technical University of Nova Scotia (TUNS), Halifax, have evaluated the use of the Sonoscan company's acoustic microscope for the detection of worms and bones in fish (Watts and Russell, 1980). The principle of its operation is described in their report:

> "The Sonic Laser Acoustic Microscope (SLAM) is a detection apparatus which utilizes sound and a laser beam to enable a display of the material under investigation on T.V. monitors.
>
> Sound which is generated by a flat piezoelectric crystal located beneath the sample is directed toward the sample at an angle of 10 degrees from the perpendicular to the plane of the sample. The angle of incidence is chosen to eliminate any standing waves within the sample. As shown in Figure 1, the sound passes through the sample and impinges on a 5 mm thick plastic cover slip causing microdeformations to the cover slip. A fine laser beam, which is focused on a semi-transparent layer of gold or aluminum on the cover slip, is swept across the cover slip. The sweep of the laser beam is synchronized with the sweep of the T.V. monitors. The distortion of the cover slip, caused by differing material propeties, causes the laser beam to be angularly modulated and through a photocell detection system the reflected light is converted into an electrical signal which is displayed, after further processing, as an image on a T.V. screen.
>
> Since the cover slip is semi-transparent the light passing through the sample is used to create an optical image on another T.V. screen.
>
> The detection modes of the SLAM unit via a complex processing of the laser and transmitted light result in three possible presentations, namely,
>
> 1. Optical picture.
> 2. Acoustic transmission picture.
> 3. Acoustic interferogram picture revealing changes in the velocity of sound within the sample."

Watts and Russell made the following observations on the use of the instrument:

(i) Using a frequency of 100 MHz, the sound penetration, which gave a sharp contrast between worm and fillet in cod, was limited to a depth of 4.5 mm. Sound penetration appeared to decrease as the fillet aged. (A quality control possibility?)

(ii) A lower frequency (e.g. 10 MHz) instrument would be required to process thicker commercial size fillets. At 10 MHz the resolution would be:

$$t = \frac{c \text{ (velocity of sound in cod)}}{f \text{ (frequency)}}$$

$$= \frac{1.55 \times 10^5 \text{ cm/sec}}{10 \times 10^6 \text{ sec}^{-1}}$$

This would be adequate to resolve bones or codworms in the fillet.

(iii) There is sufficient difference in the physical properties of the codworm and the fillet to allow the worm to be detected at a ratio of thickness of fish muscle to codworm of 4:1. In thicker fillets, scattering may mask the higher attenuation by the worm. Pictures of the codworm taken with the Sonoscan apparatus are shown in Figure 2. The worm is clearly seen and even some internal structures are visible.

(iv) A serious limitation is the small area which can be scanned at one time. While scanning and viewing are almost instantaneous, the fish would have to be moved several times to complete viewing a whole fillet. This might not be too bad if the sample could be moved continuously past the detector. However, the cover plate, fiber optics, etc. have to be repositioned for each new position.

(v) The current price of the instrument is prohibitive for its use as a quality control instrument in a fish plant.

In view of the thickness and sample size limitation and the cost factor, the authors do not recommend further studies on the use of the Sonoscan instrument for this application at this time. As an alternative they are exploring the use of a Sokolov tube as an alternative form of detector for an ultrasonic scan of the fillet. This device is less expensive and can be used to examine a larger area at one time. If its resolution capabilities are adequate, it might become an acceptable instrument for quality control use.

2. Investigations on temperature tolerance of codworms.

A. Fish plant freezing experiments.

Experiments on the tolerance of codworms exposed to freezing temperatures during normal processing operations were carried out by D. Gillis et al. (1979) of the TUNS at fish plants in Canso and Lunenburg, Nova Scotia. Over 50 experiments were performed and in the process 700 codworms were tested

for viability. Experiments were designed to obtain heat transfer and/or worm viability information. Different package sizes were compared as were freezing rates in cod and sole fillets. In temperature tolerance tests fish were candled and wormy fish were selected and placed in the centre of the fish packages. In each package six thermocouples were affixed, one on the top and one on the bottom of the box, one between the fish and the bottom, another between the fish and the box top, and two placed in the centre of the fish.

In the plate freezer experiments one pound packages of cod cooled to -20°C in 30 minutes while larger packages took correspondingly longer - a 40 pound package took about 4 hours to reach -20°C. Twelve worm viability experiments were carried out on 1 and 5 pound packages of sole and cod fillets placed in the plate freezer. The samples contained from 6 to 39 worms per package. No worms survived the normal processing time in the plate freezer. In most cases a temperature of -30°C was reached.

In similar studies packages of fish were placed in cold storage rooms. Thirteen viability studies were performed on 1 and 5 pound packages of cod and sole containing 3 to 71 worms per package. After 12 hours frozen storage the packages approached the cold storage temperature of about -20°C. No worms survived this storage period.

The authors conclude that cooling rates differ depending upon package size and also species, sole cooling more slowly than cod. Nevertheless, under regular processing conditions, all codworms are killed by the plate freezer or cold storage operations used at the Canso and Lunenburg fish plants.

B. Cooking experiments.

In a report by J.C. MacKinnon et al. (1979), the authors describe the results of experiments in which 110 cod fillet samples were subjected to one of six common cooking procedures to observe the temperature history of the fillets during cooking, and another 130 fillets were similarly treated to observe the viability of the worm at the end of the cooking process. The cooking procedures used included foil baking, deep-frying, baking, steaming, pan-frying and broiling, and are described in a Fisheries and Marine Service pamphlet entitled "Fish 'n Seafood Showcase". Thermocouples were placed in the fillets to obtain temperature readings and cooking was considered complete when the temperature reached 60°C.

No worms survived any of the cooking procedures except those in fillets cooked by baking in foil. These were in thin fillets which heated to the terminal cooking temperature in a relatively short time and the fillets did not appear fully cooked. These represent only 5 worms of 350 used in the tests.

The temperature histories indicated a wide variation in the rate of temperature increase of fillets cooked by the various procedures. This variation may be attributed to factors including fillet thickness and "consistency", temperature differences between fillet and immediate surroundings, and convective heat transfer conditions at the fillet surface.

The authors report that "On average, the fastest cooking methods (i.e. requiring the shortest time to attain 60°C) were steaming and deep-frying

(e.g. 3-6 minutes for samples to cook); the slowest method was baking (e.g. 7-15 minutes) and pan-frying and broiling required intermediate cooking times averaging about 7 minutes." Their recommendations to ensure that no codworms survive the process of cooking are:

"(1) cook according to recommended methods (e.g. Fisheries and Marine Service pamphlet 'Fish 'n Seafood Showcase'), noting especially the rules for cooking time (i.e. allow 10 to 12 minutes cooking time per inch for fresh fish);

(2) in all cases, visually confirm that the fish is cooked (i.e. test for 'doneness') after allowing adequate cooking time as mentioned under (1); this is especially important when baking-in-foil."

C. Laboratory freezing and heating experiments.

Laboratory experiments were done by D.J. Gillis and E.P. Boudreau (1979) to determine upper and lower temperature tolerances of the codworm. The authors used two experimental methods to determine the freezing temperature which killed the parasite. In one test small discs of cod fillets containing codworms in situ were cooled in a chest-type deep freeze to predetermined temperatures. Upon reaching the desired temperature the discs were removed and the worms tested for viability. No worms survived freezing below -9.2°C while none were rendered motionless at temperatures of -7.8 or warmer.

In a similar series of tests worms were placed in an aluminum cylinder, the ends were plugged with pieces of cod fillet and then closed with aluminum discs. Thermocouples were placed in the centre of the cylinder beside the worms. The containers were placed in the freezer and then removed on reaching predetermined temperatures. The cooling rates were slower in the aluminum cylinders than in the cod discs and 3 of the 268 worms cooled to -13.6 survived. Below this temperature none survived. The authors felt that there might have been some space between the worms and the thermocouple in the cylinders and this might account for the difference in lower lethal temperatures observed. They conclude that undisturbed worms in the cod fillet are killed when their temperature is lowered to -10°C.

In another series of tests 5 to 10 worms at a time were placed in mesh bags and immersed at different temperatures in a water bath over varying periods of time. All worms were killed after a dip duration of 20 seconds at 54.2°C, after 7 seconds at 57°C, 4 seconds at 60°C, 2 seconds at 62°C and 1 second at 65°C. Thus heating the codworm to 60°C for 4 seconds in the cooking process should kill the worm.

It should be noted that Ronald (1960) conducted experiments on the temperature tolerance of codworms. However, the present studies were undertaken under contract principally to determine if processing or cooking methods would kill the parasite in situ in the fish fillet.

3. Candling table.

A modified candling table has been designed and built under contract by Colwell Enterprises Limited, Dartmouth, Nova Scotia. It incorporates some design features meant to ease eyestrain and lessen fatigue. The table is shown

in Figure 3. The source of illumination is a Philip's 90 watt low pressure sodium vapour lamp. It is a high intensity light but its low wattage does not heat up the candling surface. The light is yellow, virtually monochromatic at a wavelength of 589 nm, close to the photopic vision peak efficiency of 555 nm (Illuminating Engineering Society Lighting Handbook). In addition, Watts et al. (1980) have shown that the transmission of light by cod fillets increases with increasing wavelengths found in fluorescent or incandescent bulbs. The heating effect of the light can be further reduced by moving the ballast away from the light housing.

In operation the light passes through a polaroid filter on which the fillet is placed. The fillet is then viewed through a second polaroid filter polarized at right angles to the first. This darkens the background leaving the fillet brightly illuminated. The effect is shown in Figures 4 and 5. In Figure 4 the fillet is seen as viewed through the two filters. In Figure 5 the top filter has been removed and the fillet is seen as viewed on a regular candling table, surrounded by a bright background.

The table also has a cutting board so that the operator can candle, deworm and trim the fillet at one time. Racks on each side of the table have been removed. These would support colour coded boxes of fillets, unprocessed fillets on one side, processed fillets on the other. The table is currently being tested in fish plants to see if it will work as planned and to determine if further modifications will be required.

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Legends

Figure 1 — Diagram of mode of operation of Sonoscan scanning laser acoustic microscope (SLAM).

Figure 2 — Amplitude (a) and interferogram (b) images formed by a codworm. The worm is 1.5 mm wide. The interferogram micrograph has a series of dark vertical fringes superimposed on the amplitude picture. These fringes are sensitive to sonic velocity variations (phase shifts). A shift to the right corresponds to a localized region of higher sonic velocity and a shift to the left corresponds to a localized region of lower sonic velocity. The intensity variations in the interferogram mode are interpreted in the same manner as in the amplitude mode. It is observed in the amplitude mode there appears to be a channel located in the center of the codworm. This internal detail is seen in the interferogram mode as a fringe shift associated with this channel structure. Take note that the fringes in the worm have a general, slight curvature. This is an effect of the thickness variation of the worm (i.e. cylindrical).

Figure 3 — Cod candling table: (1) is the light housing below the surface of the table. Light source is a 90 watt low pressure sodium vapour lamp; (2) is the first polarizing filter on which the fillet is placed; (3) is the second polarizing filter through which the fillet is viewed. The direction of polarization is at right angles to the first filter.

Figures 4 & 5 — In Figure 4 a cod fillet is seen as viewed through the two polarizing filters. The fillet is bright against a dark background. In Figure 5 the upper filter has been removed and the fillet is seen as viewed on a conventional candling table with a bright, eye-fatiguing background.

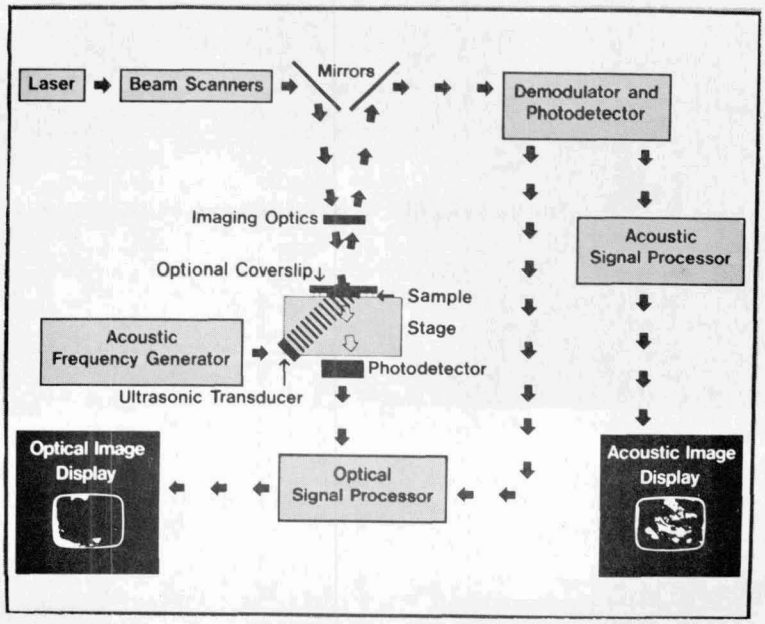


FIG 1

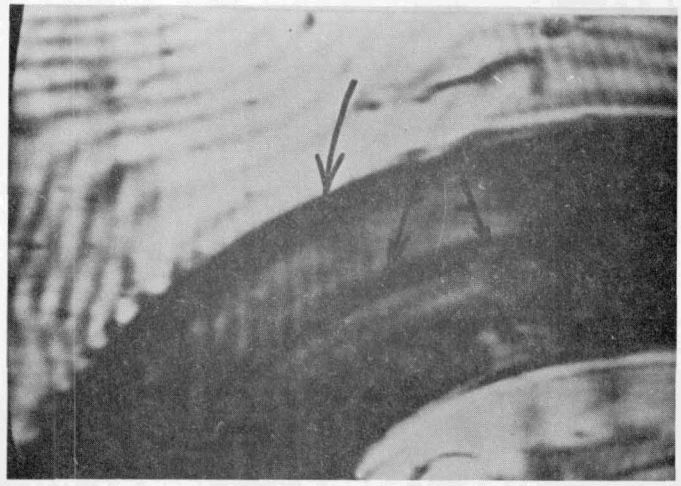


FIG 2a AMPLITUDE

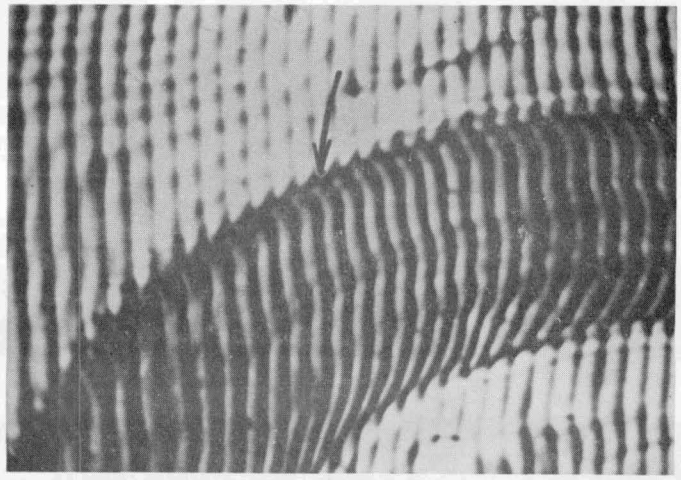


FIG 2b INTERFEROGRAM

FIG 4

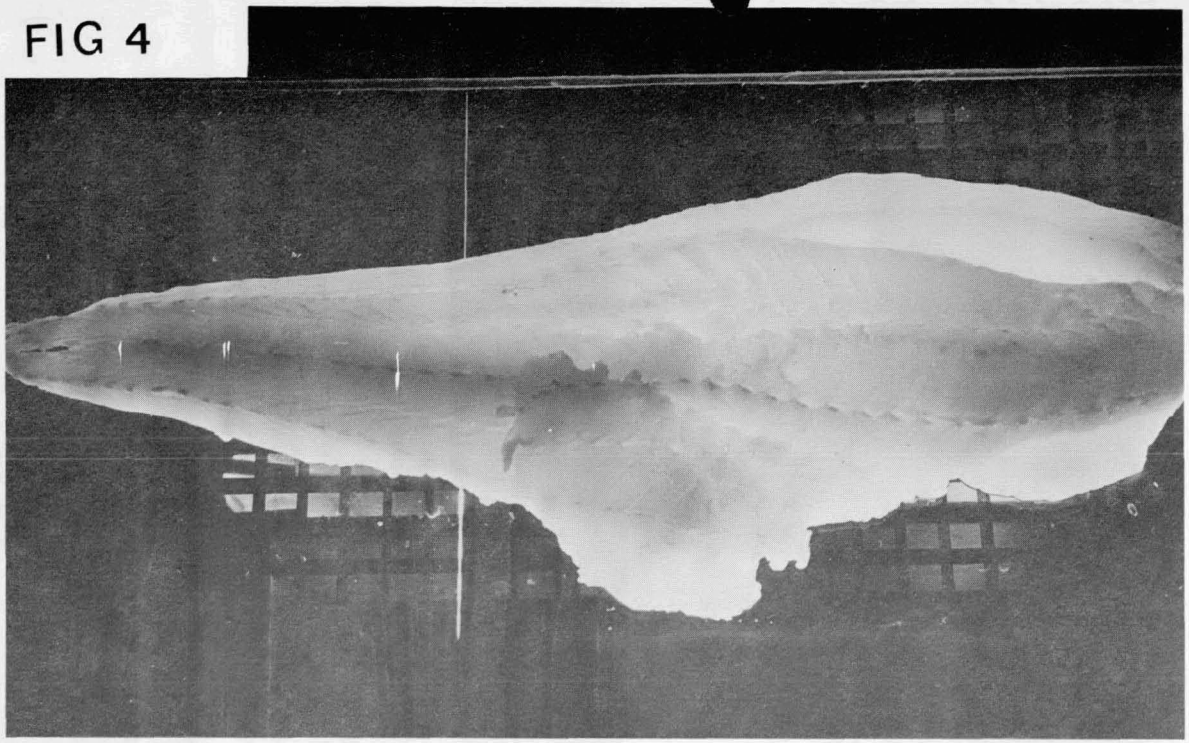
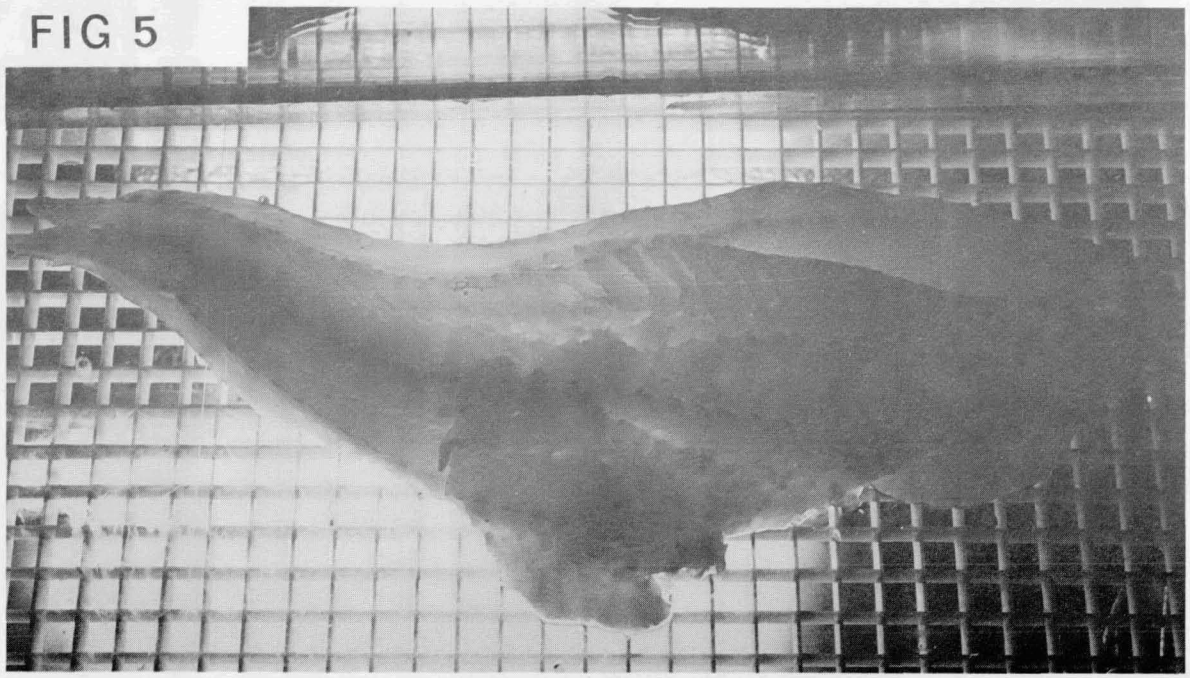


FIG 5



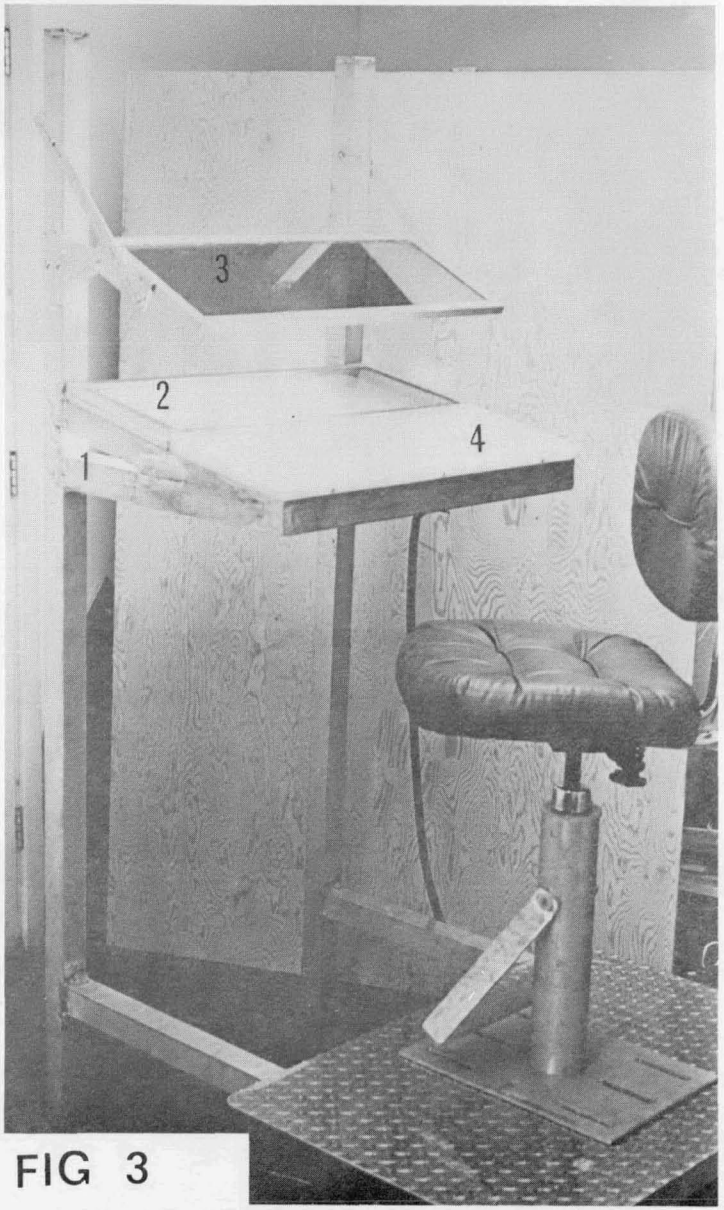


FIG 3